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INFILTRATION TO THE OUTLET SEWER OF WESTboro, Mass., was found on April 4 to be at the rate of 480,000 gallons an hour in a length of 1,950 ft. of 15-in. vitrified pipe. This was more than half the total volume of flow to the sewage filter beds. The beds are inadequate, not having been carried out in accordance with the original plans. The sewer commissioners recently engaged Mr. J. J. Van Valkenburgh, of South Framingham, to report on the ground water trouble and necessary changes in the disposal area. The engineer recommended the replacing of 1,950 ft. of vitrified pipe with 16-in. cast-iron and the construction of new filter beds. The plans were approved by the State Board of Health on May 16, with the suggestion that further studies be made to determine whether a further section of the outlet sewer should not be replaced with iron. This suggestion was due to the fact that in the section receiving ground water a fungus growth occurs which nearly clogs the sewer at times. It is feared that this may continue in the section below that recommended for relaying, unless the ground water is excluded. The sewer commissioners have recommended that the plans of Mr. Van Valkenburgh be executed.

THE CONNECTICUT STATE SEWERAGE COMMISsion bill has passed both branches of the Legislature at last, and in pretty good shape. It provides for a permanent sewerage commission of five members, to be appointed by the Governor. Each commissioner is to have a yearly salary of $500, and necessary expenses in addition, up to $500. The sum of $10,000 is appropriated for the expenses of the commission, thus leaving them $5,000 above the items already named.

BIDS FOR A WATER SOFTENING PLANT for Winnipeg, Man., are to be received by the Fire, Water and Lighting Committee up to July 3. The plant is to have a daily capacity of about 3,000,000 U. S. gallons, and a maximum hourly capacity of 180,000 U. S. gallons. A 360,000-gallon service reservoir, with 15 ft. of water, will be included in the contract. The city will deliver the water to the softening plant, by pumping; the plant must receive the water, soften it and deliver it to the service reservoir. The water as it comes from the well will pass through a surface condenser, attached to a 75 HP. compound engine, the original temperature being about 42° F. The city, as agent for the contractor, will do work and furnish material at the following prices: Earth excavation, 40 cts. per cu. yd.; concrete walls and foundations, $8 per cu. yd.; brick in cement, $23, and in lime, $15 per thousand. The city will also provide a building, outside the contract, to shelter the softening plant. Mr. H. N. Ruttan, M. Am. Soc. C. E., is city engineer of Winnipeg, and Mr. C. J. Brown is city clerk. If constructed, this will be the first water softening plant for a city supply built in America, so far as we know.

WATER FOR DOMESTIC PURPOSES IN DETROIT is to be furnished without direct charge to consumers hereafter, the expense to be met by general taxation. The cost of water main extensions is to be met by assessments upon abutting property, up to the cost of a 6-in. main. These innovations are some of the features of an act that has just passed the Michigan Legislature. The same act abolishes the water board, and places the water plant in charge of the Board of Works. The Detroit water board has been a thorn in the side of Governor Pingree for many years past, at least ever since he was first elected mayor. He has also long been an earnest advocate of abolishing water rates, and at one time was strongly against the use of water meters.

THE NEW WATER-WORKS TUNNEL AT CLEVEland had reached the following stage of construction on May 15: There remained only 600 ft. to complete the section between crib No. 1 and the shore. At crib No. 2 there has been much trouble in making the shaft tight, but this has finally been accomplished and 165 ft. of tunnel driven in one direction and bulkheaded up, awaiting the placing of an air lock. The other heading from crib No. 2 has been driven 60 ft. The superstructure of the intake crib is nearly complete, and the shaft will be started soon. Mr. M. W. Kingsley, M. Am. Soc. C. E., is Chief Engineer and Superintendent of the Cleveland Water-Works.

A VIADUCT OR TUNNEL to connect the boulevard systems of the North Side and the South Side, at Chicago, is again being proposed. The general plan for the viaduct is on a route turning east from Michigan Ave., at Randolph St., and then running north in a straight line to St. Clair St., crossing the river by a new bridge. The City Engineer has prepared plans for a viaduct composed of a double row of columns connected by transverse plate girders 4 ft. deep and 40 ft. long. Between these would be the longitudinal trusses, 4 ft. deep. There would be a central asphalt roadway 20 ft. wide, with a 7 ft. cement path for bicycles, and a 6-ft. cement sidewalk on each side. The electric light posts would be between the roadway and the bicycle paths. The cost is estimated at $170,000, exclusive of the bridge over the river. The length would be about 3,000 ft. At present the means of communication between the North Side and the South Side are awkward and of limited capacity. A subway project for the same purpose is also being revived, the main claim in its favor being the avoidance of the occasional delays incident to the use of a drawbridge. Plans for such a subway were prepared a few years ago by Gen. William Sooy Smith. There would be two 18-ft. roadways, with a 10-ft. walk between them, a subway for wires and pipes being under this walk. There would be a series of archways in the side walls between the roadway and footway tunnels. The foundations would be pile clusters with timber grillage, and underneath a large soap factory there would be placed underpinning supported by steel beams spanning the tunnel and supported by steel columns resting on the side walls of the tunnel. The maximum grade proposed is 5%, and the cost is estimated at $1,500,000 to $2,000,000.

TRACK ELEVATION IN CHICAGO is to be still further extended. On May 22, the Council passed an ordinance providing for the elevation of the Atchison, Topeka & Santa Fe Ry., and the Chicago, Madison & Northern Ry., from the 18th St. viaduct southwest to the Illinois & Michigan Canal, a distance of about four miles. It also provides for the elevation of the Chicago & Alton Ry., from its intersection with the Pittsburg, Fort Wayne & Chicago Ry. (just south of the bridge over the South branch of the Chicago River), southwest to Albany Ave. The tracks of the Union Stock Yards & Transit Co., the Chicago Terminal-Transfer Ry., and the Pittsburg, Cincinnati, Chicago & St. Louis Ry., must also be elevated where they coincide with these routes. There will be about 35 subways in all.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Burlington, Cedar Rapids & Northern Ry., about four miles southeast of Waterloo, Ia., on May 28. According to press reports the accident resulted from a washout attributed to a cloudburst, which flooded Sink Creek, and caused the water to undermine the approaches to the stone railway culvert at that place. It is stated that 7 persons were killed and 30 others injured.

A COLLISION ON THE LAKE ST. ELEVATED ROAD of Chicago, on May 30, injured 40 persons. A special train ran into the rear end of a regular train standing at a station. It is reported that the motorman of the special lost control of his train and could not shut off the electric current.

THE CORONER'S JURY VERDICT on the Exeter, Pa., collision on the Philadelphia & Reading R. R., on May 12 (Eng. News, May 18, 1899) is a censure of the company and the charging of several of the responsible employees with misdemeanor. The collision occurred between two sections of a passenger train and caused the death of 29 persons and the injury of 50 others. The first cause of the accident seems from the evidence brought out to have been the pulling out of a draw bar on a coal train, which was taking a sidetrack three miles south of Exter to allow the passenger train to pass. The delay in coupling up the broken coal train caused the first section of the passenger train to be stopped at Exter, where it did not usually stop, by orders from the chief dispatcher's office. Because probably of the unexpected order to stop at Exter the first section ran by the station and backed up its full length while the engine driver was getting his orders. This section left Reading at 8:36 o'clock, and arrived at Exter at 8:49 o'clock, having made the run in 13 minutes. The second section left Reading 6 mins. later, and collided at Exter with the first section at 8:51 o'clock, having made the run in 9 mins., and gained 4 mins. on the first section. Between Reading and Exter there are four signal cabins occupied by signalmen, whose duty it was to preserve the time interval. These cabins connect with the chief dispatcher's office, but not with each other, therefore, while the chief dispatcher may ascertain what takes place at each cabin, the other cabins have no knowledge of it. After the second section left Reading the chief dispatcher ordered the first cabin to warn it to run with great care by displaying the red and green signal. This the signalman claims to have done, but the engineer of the second section asserts that he saw only the green signal, and therefore ran less carefully than he would if he had received the red and green signal. After passing the green signal he asserts that he received the white or safety signals at all the other cabins, which assertion is corroborated by the signalman at those cabins. The chief dispatcher knowing that section one was held at Exter, and learning that the second section had passed the warning signal of the first cabin, attempted to avert any possible collision by ordering section one to proceed. Before the order could be obeyed, however, the collision took place. While the foregoing seems to be the explanation of the accident, the testimony is too confusing and conflicting to establish it fully. The coroner's jury in its verdict held that the accident was due to the following causes:

Having never established a modern and adequate system of communication between signal stations and the main office. Dispatching trains at too short intervals; failing to provide a sight and color test at least once a year for employees required to distinguish colors on signal boards at a distance; the failure to require signal-tower men and crossing watchmen to have accurate timepieces, the jury says, is censurable.

The jury also finds that mistakes were made by employees of the company concerned in the running of both section of train No. 12 on the night of the accident, but they were insufficient to have caused the collision had a proper system of signals been in use.

Summed up in a few words, the use of the time interval system of running trains seems to be the true explanation of the accident.

A SHIPMENT OF 100 STEEL CARS to Egypt by the Barber & Co.'s line arrived at Jersey City, N. J., the first of this week. These cars are a part of an order for 300 cars for the Egyptian States Railways.

THE RECORD IN STEEL RAIL MAKING is claimed by the South Mills of the Illinois Steel Co., South Chicago, Ill., which recently rolled 1,310 tons in a 12-hour run. It is stated that the best previous record for the same period of time was 1,301 tons, and this record was also made by the same mills. The men engaged in the record-breaking run were not selected for the occasion, but comprised, it is stated, the regular night shift.

THE SIBERIAN RAILWAY, says the London "Economist," will be 3,958 miles long, made up as follows: Western Siberian, 888 miles; Central Siberian, 1,149 miles; Trans-baikal, 737 miles; Eastern Chinese, through Manchuria, 1,000 miles; Ussuri railway to Vladivostock, 141 miles. But to this total of 3,958 miles must be added 1,724 miles from Tscheliabinsk to St. Petersburg; or 1,923 miles to Riga; or 2,037 miles to Libau. The "Economist" says that the railway tariff from Vladivostock to one of the Baltic ports could hardly be less than 8 to 10s. per cwt. of 112 lbs. As the water rate from Chinese and Japanese ports to Europe is now much lower than this the "Economist" believes that there is little possibility of any destructive traffic competition with the railway completed, but it thinks that the agriculture and mining developed along the line will give the railway plenty of work.

A MOTOR-CARRIAGE TRIP of 700 miles, from Cleveland O., to New York, was completed last week in less than 4½ days. The trip was made by Messrs. Alexander Winton and Charles B. Shanks, of Cleveland, in a vehicle with a gasoline motor, the tank carrying six gallons of gasoline, costing 6 cts. per gallon wholesale; and this store of fuel was found to be good for 250 miles. The motor phaeton complete weighed 1,800 lbs., and it was fitted with pneumatic tires 5 ins. in diameter and ⅝-in. thick. The start was made from Cleveland at 7 a. m. on May 22, and Buffalo, 218 miles away, was reached by 9.15 p. m. of the same day. Between Buffalo and Freeport the front axle broke and another was received from Cleveland and put in place. From Freeport to Syracuse, 80 miles, the running time was 8 hours; the 147 miles to Albany took 13 h. 55 m.; the remaining 161½ miles from Albany to New York required a little less than 11 hours. The 707.4 miles was made in 4 d. 11 h. 45 m. running time, an average of 6.56 miles per hour. The roads from Cleveland to Buffalo were fairly good, but between Buffalo and Albany they were heavy, and no great speed could be made. At times on the trip a speed of 30 miles per hour was made.

RAISING AND MOVING LARGE BUILDINGS.

Two interesting features of building contractors' work which are peculiar to this country are the facility with which buildings (large and small) are moved from one site to another, and the facility with which the lower parts of large buildings are removed and rebuilt, while the upper part is temporarily supported on timbers and screw jacks.

A more than usually difficult piece of work of

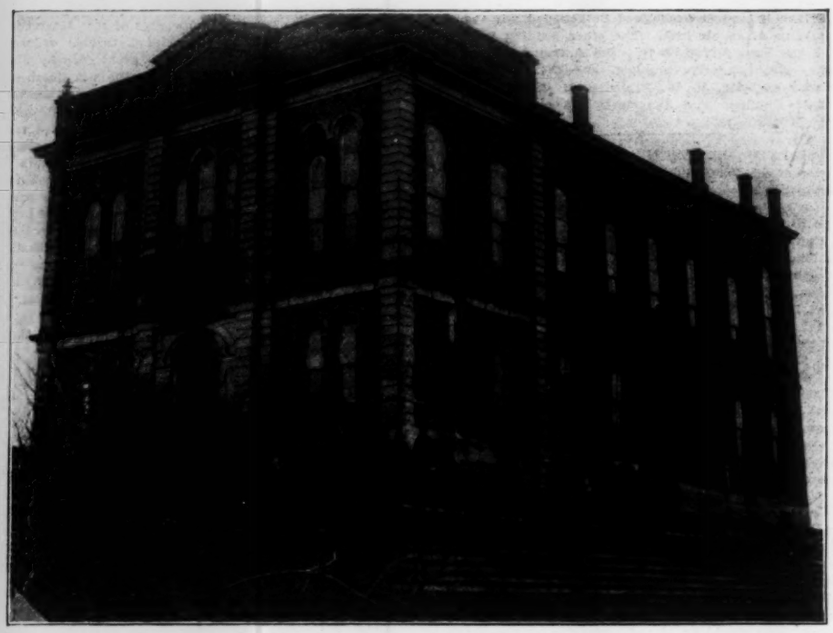


FIG. 1.—THE TOWN HALL AT WASHINGTON, PA., DURING ITS REMOVAL TO A NEW SITE.
Hollingsworth & Coughlan, Contractors.

the first mentioned description, which was carried out some months ago, was the removal of the town hall at Washington, Pa., which was moved endways and sideways, turned around, and then lowered upon its new foundation. It is a brick building, 56×100 ft. in plan, and about 60 ft. high, with a weight of about 3,000 tons. The new site is on the hillside, so that the blocking reached to the extreme height of 22 ft. The space available did not permit of turning the building round on its old site before moving it, but it had first to be moved westward endwise for 120 ft. It was then turned round about a quarter of a circle, but with an eccentric movement, one end moving 120 ft. and the other 75 ft. It was then moved sideways 130 ft. and lowered 17 ft. Fig. 1 is a view of the building, and shows the upper part of the cribbing, with the jacks and rollers, and the steel I-beams which support the cross walls of the building. Fig. 2 is a view of the front of the cribbing.

Cribbing or blocking for this purpose is usually built of pine, but in this case hemlock was used as a matter of economy. As hemlock is soft and easily compressed, however, the cribbing was built so as to give its top an incline of 3 ins. in 16 ft., to allow for settlement. Bench marks were put on surrounding buildings, and levels were frequently taken, being checked by these bench marks. Any settlement as the building moved along was compensated for by raising the grade of the next section of the crib. In turning, a lantern marked the center of the building, and all the rollers were set pointing radially to this light.

The second style of work referred to is of very common occurrence in Chicago, where the store fronts of a number of large buildings have been torn out, new columns and foundations erected, and more modern fronts put in. Fig. 3 is a view of a piece of work of this kind which was carried out last year for Mandel Bros., at the northeast corner of State and Madison Sts. The building is 52×150 ft., and the weight carried by the jacks was about 3,000 tons. This dry-goods firm already occupied the modern building adjoining the corner building, and on acquiring the latter as an extension, desired to make it conform with the other building so far as possible. Timber cribbing was built in the basement, and the supports and walls of the first and second floors were torn out, the upper walls being supported by long timbers extending from the crib work or blocking to the cap timbers, while the two floors were supported by separate systems of shorter timbers, as shown. Iron beams resting on the cap timbers carried the cross walls. Under each timber was a 5-ton screw jack, and in raising, all the jacks were given a quarter turn simultaneously on the sound of a whistle, men being posted at the heads of the timbers to watch carefully and give the signal as soon as the upper part of the structure was clear of the lower part. When thus supported, the walls and interior columns were removed and replaced by structural steel work, leaving spaces for show windows of great size. The outside finish is of ornamental work, similar to that shown on the left of Fig. 3. When this new supporting work was completed, four stories were added on top of the old building, this additional work consisting of a structural steel framework with terra-cotta tile fireproofing and curtain walls. The upper part of the other building was also altered, and both are now eight stories high, and finished in the same style, so that they resemble one large building.

Both of the pieces of work above described were executed by the firm of Hollingsworth & Coughlan, 184 La Salle St., Chicago, which makes a specialty of this class of work. We are indebted to Mr. Coughlan for photographs and other information respecting the work.

The jacks used in work of this kind are of cast iron, and are nominally rated at 5 tons capacity, but a number of these which were tested to destruction under Mr. Coughlan's direction broke at loads of 24, 25 and 47 tons. They all broke in the flange of the nut, and this part is now made heavier. Mr. Coughlan has also invented a jack with ball-bearing screw-threads. The jack has a hollow steel bar and a cast steel nut. The threads are formed by semicircular grooves in the bar and nut, and in the spiral channel thus formed are 125 hard steel balls, ½-in. diameter. These balls return from one end of the threaded portion to the other by a vertical channel in the nut. In the ordinary house raising jacks the bar let into the upright timber has a fixed cap bearing, which does not revolve and which is therefore soon ground out by the head of the bar. In the new jack, the timber rests directly upon the nut, and there is no load upon the top of the bar.

The rollers used in moving buildings are of hard maple, the log being first quarter-sawed, and a roller being turned out of each section, thus entirely eliminating the heart wood. The rollers are only roughed out at first, and laid aside to season, as if turned when green they will warp. When thoroughly dried and seasoned they are finished to the proper diameter.

THE NEW RAILWAY STATIONS AT OMAHA, NEB.

(With two-page plate.)

II.

The Union Station.

In our former article on the new railway stations at Omaha (Eng. News, May 5), we outlined the general situation and described the Burlington station in some detail. We now proceed to describe the Union Station, work on which is now in progress. This station is on the north side of the tracks, nearly opposite that of the Burlington system, as shown in Fig. 1, which is repeated from our former article. The station is parallel with the tracks and with the streets, and has its western end abutting upon the 10th St. viaduct.

The station will consist of two buildings; the passenger station proper, and a building containing the dining-room, mail and express rooms, boiler-room, etc. These are separated by a covered passageway 24 ft. wide. The buildings will be of mottled yellow pressed brick, with blue Bedford stone and terra cotta trimmings, and red tile roofs. The concourse, pavement and platforms are of concrete. The elevation of the end fronting upon the viaduct is shown in Fig. 2, while Fig. 3 is the elevation of the city front of the main building.

The main building is 276 ft. long, 80 ft. 2 ins. wide at the east end, and 75 ft. 2 ins. wide at the west end. The latter end has a two-story portion, about 40 × 74 ft., the entrance from the viaduct being upon the upper floor, which is 6 ins. above the viaduct level. Across the entrance is a canopy or shelter roof about 16 × 25 ft., supported by brackets. Fig. 4 is a plan of this upper floor.

The entrance is about 22 ft. wide, and is fitted with a row of six swinging doors, 3 ft. 2 ins. × 7 ft. 6 ins. About 10 ft. beyond is another and similar row of doors, all the doors having glass panels. This arrangement forms a storm entrance or vestibule, and provides ample doorway space, while at the same time checking the entrance of wind and cold. The second row of doors opens into the main entrance hall, 22×25 ft. On one side of this is a broad stairway leading down to the main floor, while on the other side are the elevators and a parcel check room, 17×17 ft.

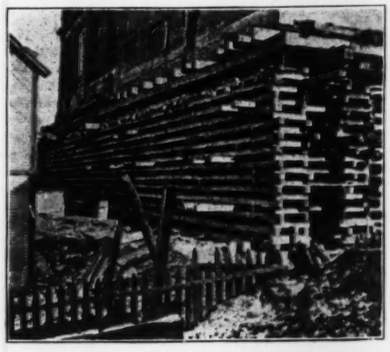


Fig. 2.—View Showing the Extreme Height of Blocking Under the Washington Town Hall.

The plan of the main or lower floor is shown in Fig. 5. Here the stairway and elevators are in a hall at the west end of the general waiting room, and at this end also are the smoking room, 25×32 ft., the barber shop, men's toilet room and station master's office, the two latter being under the approach from the viaduct to the main entrance. The waiting room is 52×112 ft., and has an entrance from the street and three sets of double

doors opening upon the platform. It is 40 ft. high to the ceiling, which is supported by steel trusses. On the north side of the room are the parcel room, ticket office (42×24 ft.), telegraph and sleeping car offices, parcel room and the baggage checking room. East of the waiting room are the women's waiting room (24×40 ft.), and toilet room, and also a large L-shaped baggage room about 75×94 ×67 ft. Underneath, and made accessible by an elevator, is an auxiliary baggage room of about the same size, for storage purposes.

Along the south or track side of the station is a platform 25 ft. wide, with a pitch of 0.4 ft. from

FIG. 3.—RECONSTRUCTION OF THE MANDEL BUILDING, CHICAGO. (SHOWING THE UPPER PART SUPPORTED BY JACKS AND TIMBERS.)

Hollingsworth & Coughlan, Contractors.

the wall to the curb, which is about 1 ft. above the level of the ties. The platform is covered by a tiled shed roof 24 ft. wide, carried by steel trusses supported on square iron columns 9 ft. from the curb line. These columns are 22 ft. 2 ins. apart, and between them is an ornamental iron fence, provided with gates at suitable intervals.

The foundation walls are of rubble masonry, with an 18-in. bed of concrete under all the footings, while the footings under the three-story end of the building are reinforced by rows of 7-in. or 8-in. I-beams, laid upon the 18-in. bed and then filled in with concrete. The piers supporting the I-beams of the first floor are of rubble masonry, 21 ins. square. All these piers rest on concrete, and have caps of 8-in. dimension stone. Under the main waiting room the piers are spaced 11 ft. 1 in., c. to c., longitudinally, and 8 ft. 10 ins., c. to c., transversely of the building. Elsewhere, the spans between the piers, and from the walls to the piers, range from 8 ft. 10 ins. to 12 ft. 1 in. The height from the base of the concrete foundation to the main floor is 12 ft. 6 ins., and the basement floor is 10 ft. 6 ins. below the main floor.

The framing of the main floor consists of 8-in. and 9-in. I-beams, weighing 18 and 21 lbs. per ft.; while channels of similar sizes (11¼ and 13 lbs. per ft.) are let into the walls and secured by wrought iron anchors. This framing is shown in Fig. 5. Brick arches are built between the beams, and covered with concrete. In the baggage room, 18-in. beams and channels are used, with shelf angles 4×4 ins., riveted to the web to carry white pine floor beams 4×12 ins., spaced 18 ins. apart. The framing of the main entrance hall (on the viaduct level) is of 15-in. 42-lb. I-beams, which carry a flat arch tile floor.

The high roof over the waiting room is supported by four steel triangular trusses, 49 ft. 4 ins. clear span and 19 ft. deep. The trusses carry six purlins, two of which are 12-in. 20-lb. channels, and four are 12-in. 31½-lb. I-beams. On these are wooden rafters 2 × 8 ins., 16 ins. apart. The lower chords of the trusses carry ceiling joists 2 × 12 ins., set 12 ins. apart, and having bridging pieces between them. The roof covering is of tiles. The upper entrance hall has an arched ceiling carried by three steel trusses of 26 ft. span, each truss having a semicircular chord of two angles ¼ × 2½ × 2½ ins., the top of which touches the horizontal upper chord, composed of two angles ¼ × 2½ × 2½ ins. The chords are also connected by spandrel bracing, while the trusses are connected by T-bars, 3×3 ins., riveted to the upper side of the arched chords. The trusses are riveted to vertical posts of lattice construction, which rest upon two pairs of 24-in. I-beams at the springing line of the arch, 20 ft. 3 ins. above the floor level. These posts extend up to the flat roof, carrying lines of 10-in. I-beams which support the roof rafters, 2×6 ins. Above the arch, the posts are connected by vertical diagonal bracing. This construction is shown in Fig. 6. The side roofs have girders of 8, 10 and 12-in. I-beams, and transverse ceiling girders of 15-in. I-beams, placed singly or in pairs. The latter girders carry ceiling posts of 6-in. I-beams.

Over the baggage room, and set longitudinally of the building, are three parallel-chord roof trusses, 70 ft. 10½ ins. long and about 9 ft. deep. These are built up of angles and channels, as shown in Fig. 7. One end of the trusses rests on a 7-in. cast iron column, with metal 1 in. thick, as shown in Fig. 5. Above the trusses are I-beam posts of varying height to fit the slope of the roof. These posts carry I-beam purlins, on which rest the rafters, 2×10 ins., 12 ins. apart.

The roof over the 28-ft. passageway, between the two buildings, is carried by 15-in., 42-lb. I-beams. Fig. 8 shows the construction of the platform roof.

The express building is a one-story structure 220 ft. long and 50 ft. wide, with a basement floor 11 ft. 4 ins. below the main floor. Its construction is in general similar to that of the main building, but the style of treatment is, of course, very much simpler. It has rubble masonry foundation walls and piers, with concrete footings, and the upper walls are of brick, with stone facings. Where the foundation walls are close together, the floor is carried by wooden beams 3×14 ins., 16 ins. apart. For spans of over 15 ft. 6 ins. these beams are supported by 16-in. steel I-beams, resting on the walls and on intermediate piers. Over the boiler room, which is at the east end of the basement, the framing is of 20-in. I-beam girders and 12-in. I-beams for the brick arches.

The roof is supported by five triangular steel trusses of nearly 50 ft. span, 9 ft. deep at the middle. The I-beam purlins rest on top of the trusses, and on the track side each truss carries a 6-in I-beam post, supporting a line of purlins, with horizontal tie-beams 2×6 ins. connecting the main rafters, which are 2×8 ins., set 36 ins. c. to c. The roof is of tiles, laid on 2 × 4-in. sheathing. The construction of this roof is shown by the cross-section of the building, Fig. 8, which also shows the details of the platform roof trusses.

All the rooms are 47 ft. wide, the full width of the building, and they include the following: dining and lunch room, 53 ft. long; kitchen, 20 ft.; conductor's room and telegraph office, 17 ft.; train-box room, 11½ ft.; mail room, 16 ft.; American Express Co.'s room, 32 ft., and Pacific Express Co.'s room, 59 ft. Under the latter is the boiler room, 59×47 ft., entered by an outside stairway across the end of the building. Outside the boiler room and under the platform are a coal bin and ash pit, with scuttles in the roof (at the platform level). At the north corner, and outside the building, is a brick smokestack 80 ft. high. The inside diameter is 4 ft., and there is an air space between the 9-in. inner wall and the outer wall. A funnel 4 ft. 6 ins. wide, with masonry walls and a roof carried by 4-in. I-beams 4 ft. apart, connects this building with the main building, and in it are laid the steam heating pipes, etc.

The station will be lighted by electricity, current being generated by an independent plant driven by two 75-HP. engines. There will be about 300 incandescent lamps of 16-c. p., 20 long-burning enclosed-arc lamps, and 15 series-arc lamps of 2,000 c. p. It will be heated by exhaust steam from the two engines.

Along the south or track side of the station is a platform 35 ft. wide, with a pitch of 0.4 ft. from the wall to the curb, which is about 1 ft. above the level of the ties. The platform is covered by a tiled shed roof 30 ft. wide, carried by steel trusses supported on square iron columns 9 ft. from the curb line, as shown in Fig. 12. These columns are 22 ft. 2 ins. apart, and between them is an ornamental iron fence, provided with gates at suitable intervals. Beyond this platform will be eight tracks, in pairs, 12 ft. c. to c., except that the centers of the outer pair will be 13 ft. c. to c. The distance between these pairs of tracks is 27 ft. 4 ins., leaving room for platforms about 20 ft. wide. The platforms will be about 600 ft. long, and will have "umbrella" roofs. An additional track runs down in front of the express building, for the convenient handling of coal and ashes at the boiler room, above described. There is also a stub track at the west end of the station.

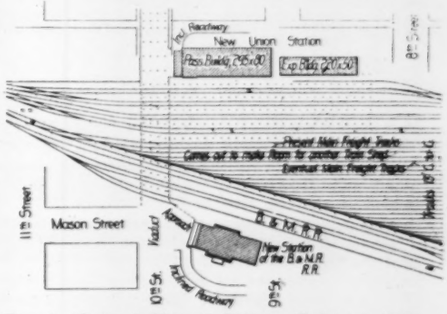


Fig. 1.—General Plan of Railway Tracks and Approaches at Omaha, Neb.

The architects for the new station are Frost & Granger, 806 The Temple, Chicago, to whom we are indebted for plans and other information. All the work is in the hands of the architects and the division superintendent, Mr. E. R. Griffin, under the general supervision of Mr. J. B. Berry, Chief Engineer of the Union Pacific Ry. The cost is estimated at $175,000 for the building, exclusive of the trainshed; and $300,000 for the work complete.

The contract for the building was let in October, 1898, to the Grace & Hyde Co., 414 Tacoma Building, Chicago, while John Rowe, of Omaha, has the subcontract for sewerage, plumbing and gas fitting. The building is to be completed by Sept. 30, 1899.

A Comparison of the Stations.

The construction of two handsome railway stations in the same city, at nearly the same time, and exactly opposite to one another, suggests a brief general comparison of their main features. First of all, attention may be called to the possibility that better facilities and better economy in construction, operation and maintenance might have been obtained by the construction of a single union station, having offices in two side buildings, with a trainshed over the tracks between them. Such a station would have afforded an exceptional opportunity to the architect and engineer for the design of a fine building and a fine example of railway station architecture. The passenger traffic comprises about 80 trains per day, of which the new union station will take about 75%, and this traffic is certainly not too much for one station. The establishment of a union station was the basis upon which all the earlier projects were planned, and we are inclined to think that this was the right idea. All the tracks and stations are on one site, so that no change in location would have been necessary, but only a rearrangement of the station tracks to facilitate train movement and station business, and to economize in the space required for the trainshed. The old union station at Toronto, Ont., was an example of such a general plan, the Canadian Pacific Ry. occupying the building on one side of the trainshed, while the Grand Trunk Ry. occupied that on the other side. However that may be, and whatever may have been the reasons for independent action on the part of the Omaha railways, the two separate buildings were decided upon, and one of these is completed, while the other is already under construction.

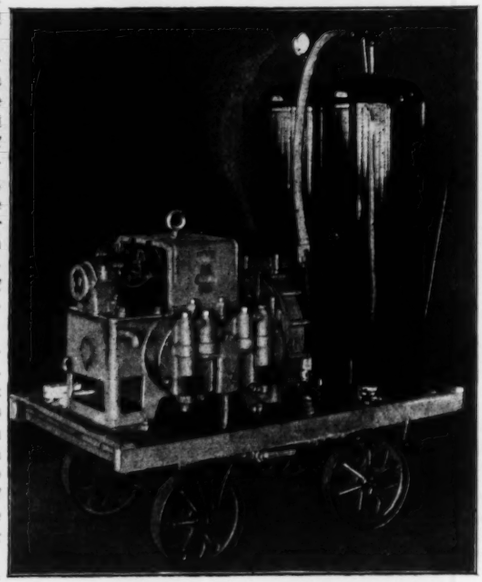
The two stations are of entirely different architectural styles and treatment, but it is rather curious that neither one has the conspicuous clock tower which has so frequently been considered as an almost indispensable feature of railway station design. The sunken entrance of the one has been criticised, as already noted, while the entrance to the other is commendable for its arrangement of doors, which can be kept permanently open in fine weather, but will form a good storm excluding device when closed.

Both station buildings are approached by a viaduct crossing the tracks, but while one has its main floor on the upper level, the other has its main floor on the track level. The latter seems to be the better plan from a railway point of view, since passengers usually prefer to wait in close proximity to the platforms, where they can look out for their trains and be ready to go directly to them. With the main waiting room on the upper floor there will probably be a good deal of unnecessary going up and down stairs, and of unnecessarily long waiting on the lower floor. As most of the passengers will use the viaduct entrance, the waiting room on the lower floor will also be much more free from draft and cold, than the one which is entered directly from the viaduct. In both stations, however, there is the very general but very objectionable feature of making the main waiting room the main thoroughfare to the trains, causing unnecessary disturbance to persons who are using the room for its proper purpose. The objections to such an arrangement were discussed in an article on "The Design of Railway Stations" in our issue of Jan. 12.

While one station confines all offices in one building, the other has two separate buildings. This is mainly a matter of design and available space, but the latter plan has certain advantages in keeping the express business more out of the way of passengers, and sometimes in avoiding the use of basement rooms. The placing of the lunch room in the smaller building instead of in the main building, does not seem to be a systematic or convenient arrangement, however, especially as there is no direct access to this room from the main building. As far as convenience is concerned, it would seem better to have placed the lunch room in the main building, and the baggage room in the auxiliary building with the express rooms, conductors' offices, etc. For electric lighting, one station will have its own generating plant, while the other will take current from the city lighting circuits.

One other point to which we may refer is that of the platform shelters. Neither station has a trainshed, but both have platform roofs, while one has a roof over part of the inner tracks, affording some protection to passengers passing from the main platform to the first island platform. Umbrella roofs, however, give but little protection from the weather, and in view of the heavy traffic and of the severe winters of that region, it certainly seems as though the better plan would have been to cover the tracks by a trainshed, so that the trains and passengers might be entirely under cover, and the work of handling baggage, etc., could also be done under cover.

There are other points in the designs which afford an opportunity for comparison, including matters of detail, and also the general layout of the various rooms and offices used by passengers, but these we cannot now take up for consideration. In our issue of Jan. 12, and in another column of this issue we have discussed some of the principles and important features in regard to the design of railway stations, which may be appropriately considered in connection with the present article on the new stations at Omaha.



Portable Air Compressor, Driven by an Electric Motor.
Christensen Engineering Co., Milwaukee, Wis., Builders.

PORTABLE AIR COMPRESSOR PLANT WITH ELECTRIC MOTOR.

In the erection of the structural steel work of the new Post-office building in Chicago, compressed air for the riveting hammers is supplied by an interesting portable plant driven by an electric motor. The entire plant, as shown in the accompanying view, is very compact, and is mounted on a four-wheel truck which can be hauled around by hand. The total weight is about 1,400 lbs., and the compressor has a capacity of 50 cu. ft. of free air per minute. The current is taken from the wires used for the electric lights on the work. The plant was built by the Christensen Engineering Co., of Milwaukee, Wis., and we are indebted to the builders for photographs and particulars.

The air compressor is of the style which the company is putting on the market for operating air brakes on street cars, and all its working parts run in an oil bath. The electric motor is mounted on top of the compressor, and drives it by a pinion and spur wheel of special design, the gears forming sections of a true helix. In this way their operation is made practically noiseless, and their durability is said to be 25% greater than that of gears with square-cut teeth. The action of the compressor is automatically controlled by a governor which is operated by the air pressure in the reservoirs, starting and stopping the compressor when certain minimum and maximum pressures are reached. The reservoir is fitted with a short hose and an air-brake hose coupling, to which the hose leading to the work is attached. No water jacket is used, and it is found that compressors of this type will run at the rate ordinarily required without any undue heat. This reduces the weight and simplifies the construction of the machine. In practice the entire apparatus, with the exception of the reservoirs, is enclosed in a water-tight wooden case, fitted with doors, which give access to the various parts for inspection, oiling, etc.

Compressor plants of this kind can be used for various purposes, wherever electric current is available, such, for instance, as operating pneumatic riveting, drilling and calking tools, cleaning car cushions, etc. The builders are prepared to furnish them in different sizes, the capacity ranging from 10 to 300 cu. ft. of free air per minute.

THE DEVELOPMENT AND OPERATION OF A LOCAL ELECTRICAL TRANSMISSION SYSTEM.*

By W. S. Barstow, M. Am. Inst. E. E.†

When the Union station was first discussed, the Brooklyn Edison Electric Co. made every endeavor to weed out all details that tended to poor economy, and thus start the system with a modern, up-to-date generating plant. Among the various items discussed was the question of station auxiliaries. As a result of these investigations the Union station was designed and equipped with all auxiliaries electrically operated, the steam from the boilers being used only in the main engines.

There is often brought forward the question as to whether the loss in feed-water temperature, etc., will not more than balance the high efficiency of the electric auxiliary. Owing to the fact that it is impossible to find two plants of equal size operating under similar conditions, and exact actual general comparison between steam and electric auxiliaries is difficult to obtain. The ideal conditions of a steam auxiliary in regard to efficiency would be: first, no loss of radiation from supply piping or the device itself; second, sufficient waste exhaust to be entirely condensed in a supplementary heater at all station loads; and, third, the replacing of such condensed exhaust back in the boiler. Under these ideal conditions all heat units of the exhaust of the auxiliary could be recovered, and such a system would be perfection. In the ordinary central station we find that the radiation of supply piping and the pumps themselves involve a loss of 25%, and that the pumps require more steam than can be condensed by the feed-water heater, owing to the presence tions of load, thereby allowing surplus steam or heat units to escape to the atmosphere, and also that it is impractical in the majority of cases to return to the boiler the steam condensed by the feed-water heater, owing to the presence of oil, and that the methods of separating the oil from such water are naturally slow and in themselves involve a loss of heat or expenditure of energy. Thus the entire problem becomes one of actual practice rather than theory.

With electric auxiliaries driven from the main engine, or auxiliaries connected with the main engine, the economy of the auxiliary is very nearly the economy of the main engine itself. In other words, the electric auxiliary can develop a horse-power on the shaft of the pump with about 18 lbs. of steam, including losses. This is about 1-5 of the energy required by a steam auxiliary best suited to the conditions; but, on the other hand, the electric auxiliary returns no energy back to the plant, and a certain allowance must be made for the loss in feed-water temperature. In considering the two systems in any individual plant, comparison should be made both with systems using economizers and exhaust heaters, one using supplementary heater with steam auxiliaries and the other electric auxiliaries without supplementary heater. In many cases the highest efficiency can, no doubt, be secured by using a few steam auxiliaries that would furnish just sufficient steam to be condensed in the supplementary heater, varying the use of the steam auxiliaries with the load.

The actual energy required by the electric auxiliaries at the Union station, with a load of 2,732 I. HP. on the main engine, is as follows:

Air pumps on surface condensers	11.6	Elec. HP.	or 0.42%
Circulating pumps on surf. cond'rs.	14.4	"	" 0.53%
Boiler feed-pumps	23.6	"	" 0.87%
Total of main auxiliaries	49.6		1.82%

*Abstract of a paper read before the National Electric Light Association at its 22nd convention, New York City, May 23-25, 1899.

†Gen. Supt. Edison Electric Illuminating Co., 360 Pearl St., Brooklyn, N. Y.

Reducing this to indicated horse-power at main engine, gives 66.8 I. HP., or 2.45% of the total steam used in the station.

Circulating Condensing Water.

In addition to reducing to a minimum the energy required by the station auxiliaries under ordinary conditions, the building was so constructed as to alter somewhat the conditions and reduce to a considerable extent the amount of work itself which the auxiliaries were to accomplish. This applied particularly to the method of circulating the water for the surface condensers. Two large tunnels, each 12 ft. high and 8 ft. wide, were constructed, side by side, beneath the entire foundations of the building, with their openings below the mean tide level and extending out into the bay. These tunnels, extending directly beneath the large surface condensers, are always filled with water, which rises and falls in both tunnels equally, according to the tide of the bay. The circulating water is taken from one tunnel by a direct-connected electric centrifugal pump, passed through the surface condenser and discharged into the other tunnel, the discharge pipe extending below the lowest water level. This construction forms a water loop in which both legs are of equal length, and in which loop are located centrifugal pump and surface condenser. Thus, when the water is once started, the columns balance one another, so that very little power is required by the centrifugal pumps. In order to prevent an air pocket from forming and breaking at intervals the discharge column, an air-pipe connection is carried from the top of the discharge opening in the condenser to the air pump, a very slight turn of the valve sufficing to keep all of the air out of the system. Whereas, under ordinary conditions, about 26 HP. would be required, under these new conditions but 7 HP. is necessary to circulate water sufficient for furnishing 26 ins. of vacuum to 1,500 HP.

Driving Field Exciters.

Among the auxiliaries might be classed the generator field exciters. The question of economically exciting the fields of large alternators has been one which has often been overlooked to a large extent as a matter of small importance. Exciters directly connected to the shaft of the engine operating the alternator, or belted to the same shaft, have introduced more or less trouble, as any variation in the speed of the main engine produces a cycle in variation of field regulation which is at once disastrous to the good operation of the system. After carefully studying the subject, the following plan was adopted in the Brooklyn installation:

A high-tension, synchronous motor, directly connected to a low-tension, direct-current generator, is directly connected to the bus-bars of the station, to which are connected the main alternators. The low-tension, direct-current generator, connected in multiple with a small regulating storage battery, excites the fields. Should the voltage on the main system vary to a greater or less extent, no variation occurs in the voltage of the field excitation, since the synchronous motor, which depends for its speed on the speed of the main generator, and not on the voltage, supplies power to the direct-current exciter. Should the speed of the engine vary to any extent, the battery acts as a regulator. The battery also is of such a capacity that the entire exciting set can be shut down for one hour without any variation in the exciting voltage, the battery automatically discharging. If, in place of a synchronous motor set, a rotary transformer were used, the result would be somewhat unsatisfactory, since a variation in voltage, as well as speed on the main generator, would affect the field current. Of course, belted or direct-connected exciters can be used with the battery with equally good economical results, but independently operated exciters furnish a more flexible system.

High-Tension Switches.

In the designing of a switchboard for high-pressure work special attention should be paid to the simplicity of arrangement and contents of such board, as the fewer the devices, the better for the reliability and success of the system. The conditions of the operation of a high-tension multiphase system, when used for distributing purposes to sub-stations, differ considerably from the requirements of a primary station with a simple distributing system. This difference lies mainly in the fact that feeder regulation in the high-tension multiphase transmission system can be almost entirely dispensed with, the sub-stations doing the necessary regulating for the energy as required by the customers. Therefore, the important requirement in the multiphase transmission station becomes simply the positive controlling of the energy generated at the machines, with possibly the operating of one or two sets of auxiliary bus-bars. For the controlling of this generated energy, switches, capable of breaking a full and overload current, should be placed between the generators and the bus-bars, and between each set of bus-bars. This requirement will be found to be imperative. In Brooklyn these switches are operated by electrically controlled pneumatic attachments, similar to those used by the Pennsylvania R. R. system in its large switch yards. In all cases these have been positive and satisfactory in action. It is the present intention to control the interlocking circuit by a device dependent upon the synchronizing of the current, so that two machines or sets of bus-bars cannot in any way be accidentally connected when out of phase. The switch itself, breaking under oil, is not in any way complicated, and has satisfactorily withstood the test of capacity and time. These main switches, placed as above stated, are the only ones in the station which will break under overload and pressure of 7,000 volts, with the exception of the emergency switches. These emergency switches are plain pivoted copper blades, with a fuse in multiple, and are to be pulled only in a case of last resort in event of any accident happening to the switchboard itself.

Requirements of Steam Engines for Driving Alternators in Parallel.

The connecting in multiple of large alternators has always proved an attractive subject. The parallel operation of small, belted, high-speed alternators has been accomplished from the beginning of alternating-current history. Even under these simple load conditions, however, it was often found inadvisable to operate in multiple longer than was necessary to transfer the load. At the present time, however, the alternating system having passed its one-machine limit, it becomes a commercial necessity to operate continuously in multiple. Central-station conditions of the present time require that the engines be slow-speed, that they be of different type, size and speed, and that the distributing system contain synchronous and non-synchronous apparatus in different forms; an entirely different situation from that of the early days with the high-speed belted generators and steady lighting loads.

The paralleling of alternators depends primarily upon the prime mover and character of apparatus employed in the distributing system. Under its simplest form a steam engine is in itself a poor prime mover for any work which requires a uniform rotation, whereas a water-wheel meets more nearly the requirements of electrical operations. In order to counteract and balance up the movements of reciprocating parts of the engine, it is necessary to store up energy at one time and liberate it at the next. This effect is generally secured by means of a flywheel.

Hitherto, the selection of a one, two or three-crank engine has been a matter of choice depending upon space, economy, first cost, etc. Having selected, based upon these items, a particular type of engine, the requirements of the generator and multiple operation has been accomplished by the simple addition of a flywheel. If, after obtaining by this flywheel method a prime mover with a variation in angular velocity of about ½%, a direct-connected generator with a constant load is added, and the set properly operated, no fluctuating or noticeable disturbance is evident; but should a second unit, constructed exactly similar to the first and with an equal weight of flywheel, be thrown into parallel, there is often noticeable a pumping effect or cross current, which seriously interferes with the operation of the distributing system. Even if two steam units were built from the same set of patterns, and were operated at the same steam pressure, it would never be possible to keep a fixed point on one exactly opposite a fixed point on the other for any long period of time, so that in order to keep these fixed points together a certain amount of energy must be expended by the generators. Thus the generators, having once been thrown into step, are called upon to make up in electrical energy all the differences in speed-changing tendencies of the two prime movers. This effort on the part of the generators themselves to balance up the unequal momentum of flywheels, and store up and liberate energy, is represented by actual horse-power, shown in heavy cross currents alternately swinging from one generator to the other. This energy, we might say, is not apparent as a total, since it is first on one unit and then on the other; but it nevertheless exists, and, under certain conditions, may detract from the useful capacity of the generator itself. If in the choice of the type of engine there should be considered the question of variation in angular velocity as accomplished by the number of cranks, so that it might be possible to use a lighter flywheel, a point in the weight of the flywheel can be reached where, in comparison with the frequency of the alternator, a minimum synchronizing power is required. This is by far the preferable solution of the difficulty, and, in fact, will be a requirement where the frequency is fairly high (about 60 cycles), and the speed low (about 75 revolutions).

All cross currents generally emanate from one of two sources: First, they may be wattless, showing the transferring of current not real energy, which, while not affecting the system, will heat up the generators. This shows a poor adjustment of fields, which, to obtain the best result, should be so regulated as to give a slightly leading or lagging current, leading in all cases preferred. Second, they may be watt or power currents, showing the transferring of real energy, which will affect the system, besides heating up the generators. This shows a poor design or adjustment of the prime mover in regard to variation in angular velocity, sometimes even caused by the engine designer using too heavy a flywheel—a flywheel which will be more than enough to give a minimum variation in angular velocity. In other words, there exists a certain synchronous relation between the speed, the momentum of the flywheel and the load, and hunting is sure to result if the correct relations are not observed.

The influences of a synchronous load upon multiple operated generators is a question of very great importance. Under certain conditions generators can be operated in multiple with perfect results on a steady static or non-inductive load, but when to the system is added a large proportion of synchronous motors and rotary transformers, poor results often occur. The swinging or cross-current effects, which are entirely absent on two well-designed units operated in multiple, often appear to a very great extent when synchronous apparatus is used on the system. In other words, an alternating system with synchronous apparatus operated at highest power factor is in a continual state of unstable equilibrium or see-saw, and any inequalities of movement of any of the moving masses, whether on prime mover or transforming apparatus, tends to disturb the system to a greater or less extent.

After once obtaining a satisfactory prime mover, the question of controlling and distributing the load on multiple-operated units must be considered. It is best that the governors of all engines should be sensitive as applied to full and no-load regulation, as thereby a constant frequency is secured, but that these same governors should be sluggish when it is necessary to take care of any sudden variation in speed, so as not to cause a variation in angular velocity. The controlling of the governor to the extent of the difference in speed between no load, full and overload should be in the hands of the electrical gallery operator, as by the independent controlling of the speed of the engine the load should be adjusted on the different units. Such an independent regulating device can easily be attached to any type of governor, and may be either hydraulic, pneumatic or electrically controlled.

Distributing High-Tension Currents.

Distribution from a high-tension multiphase plant is an important problem, particularly as regards the underground and overhead conductor systems. In Brooklyn, with a view of securing the best service on feeders, which must necessarily be overhead, heavy chestnut poles of about 45 to 50 ft. in height, and about 90 ft. apart, were used. The poles are fitted with special six-pin cross-arms. On the outside insulators of the top cross-arm are attached barbed galvanized-iron wires, which are grounded at every fourth pole. The second cross-arm carries the feeders in duplicate, three on each side of the pole. With three conductors on a horizontal cross-arm, we are able to reduce inductive effects by transpositions, which, at low frequency, are satisfactory. The insulators are of glass, of the double or triple-petticoat type, and during the two years they have been in use, no defects whatever have developed. The line is carried entirely over all obstructions, in some cases it being necessary to use 70-ft. poles. More or less trouble has been experienced with lightning, and the heaviest trunk lines have been equipped with lightning arresters.

In considering the question of an underground system for high-tension work, three important points arise: first, the style of conduit; second, the style of the insulation of the cable; and, third, the mechanical protection of the cable.

The style of conduit used in Brooklyn may be termed a closed system, owing to the fact that it has been the endeavor to keep the entire conduit system as water-tight and dry as possible. A vitrified tile duct is used, with water-tight joints, and the brick manholes are of double construction, filled in with tar, and built on heavy concrete foundations resting upon creosoted timbers. The covers of the manholes are patterned after the Edison ten-stub junction-box top. The inside cover is provided with a rubber gasket, and is held in place by bolts. The outside is simply a heavy cover, acting as a mechanical protection to the inside one. The conduit system is connected to the unused brick stacks of the stations in which steam has been removed and transforming apparatus substituted. In addition, a blower is operated at the Bay Ridge station. The movement of air through such a large system, composed of some 100 miles of duct, is very slow, and yet it is sufficient to keep the system in good condition.

The reason for the adoption of a tile conduit as moisture-proof as possible was in the main on account of electrolysis. In making preliminary tests along the proposed line of conduit it was found that the pressure from metallic substances to ground varied from 10 volts negative to 26 volts positive. Thus it would only be a question of time before the heaviest lead cover would be totally destroyed. It was also found that the only solution was to make the lead cover of the cable negative to ground throughout the entire system. Such a condition required that the lead covering of all the cables should be connected to the negative bus-bars of the railroad power houses by insulated conductors of low resistance.

The Insulation and Testing of Cables.

The materials for insulation of conductors seem to have narrowed down to two in number, paper and rubber.

Three methods of arranging conductors for three-phase work are in use up to the present time: First, concentric cables; second, three-conductor twisted or "clover-leaf" cable; third, three distinct and separate conductors. Each of the above arrangements has its own particular value, depending on local conditions and requirements. All con-

centric cables should have the outside conductor grounded, to protect them from the increased pressure due to their arrangement. It is a very difficult form of conductor to handle, and it is not of any particular advantage except in very high frequencies. The three-conductor twisted or "clover-leaf" cable is the arrangement generally provided for in all large installations, as on a frequency of 60 cycles, or under, the inductive effect is very small, and the arrangement of conductors gives a strength that is very necessary for the life of the cable. Separate conductors, separately insulated and drawn into different or the same ducts, can be used with a frequency of about 25 cycles without any noticeable effects from induction, and in many cases this arrangement is much preferred, as defects are easily repaired, and one extra conductor gives the advantage of a duplicate feeder as far as accidents are concerned.

Paper insulation, when made up with a liquid compound and of sufficient thickness, and when carefully laid, possesses some advantages, especially when such a cable can be laid for all time and need not be withdrawn and laid in other locations. Almost all defects in paper cable develop at bends; but if such bends are carefully made and the cable carefully handled in the laying, it is as satisfactory and lasting as any insulation in the market, as it is composed of material that is naturally homogeneous in its "make-up." Rubber insulation, unless properly specified, is somewhat uncertain, as the term "rubber" has come to include a variety of compounds which, although insulators momentarily, become fair conductors after short use. Up to within a short time ago it was sufficient to test cables with 50% higher voltage than that which they were expected to carry, the test being made by placing the cable in a tub of water. In multiphase work, and especially in large installations, many phenomena occur which require that the specifications should be more rigid. Resonance and induction under certain conditions produce effects that for an instant more than double the pressure on the system, such high pressure occurring at different points or nodes, and in no way affecting the ordinary operation of the system. This was ascertained in Brooklyn by the placing of spark gaps set for 12,000 volts at pre-determined points on the system. In the event of sudden grounding of an outside conductor on overhead line, the current invariably jumped the spark gaps at these points, although no effect was noticeable on the working system, the pressure at the generating and sub-stations remaining steadily at 6,000 volts. There also exists the possibility of some careless attendant in some unusual excitement throwing in multiple two generators which are not in exact phase, this resulting in a sudden increased pressure. The adjustment of the power factor in a distant sub-station will even cause these waves to appear and pressure to be built up at certain points without seriously affecting the instruments at the stations. In order, therefore, to provide for all such emergencies, no cable should be purchased or installed unless it will stand for one hour at least double the working pressure, this being equivalent to a puncture test of more than three times the working pressure.

A cable as ordinarily made up provides for half the insulation between ground and conductor as between conductors themselves. In order more evenly to distribute operation, should be sufficient, but when practical experience is referred to it is often found, where overhead conductors are employed, that one conductor of the system may become temporarily and accidentally grounded, in which case the same pressure with half the insulation exists between ground and conductor as between the conductors themselves. In order more evenly to distribute the strain of the cable, "split" insulation has often been used. This arrangement provides for an insulation around each conductor itself, and an insulation around all three conductors when made up and before the lead covering is put on, thus making the insulation between the lead covering and any one conductor the same as that between any two conductors. The thickness of the insulation itself will depend entirely upon the lasting quality of the insulator rather than on the ohmic resistance of such insulator. In other words, an insulator with low ohmic resistance may be preferable to an insulator with high ohmic resistance if its quality is more lasting. Cables with very high insulation have been known to break down suddenly, while cables with a low insulation have been known to last indefinitely.

The question of mechanical covering for the cable itself depends upon the nature of insulation, the liability to electrolytic action or the effect of gases. Paper cables must necessarily be covered by lead or other moisture-proof material, the life of the cable depending upon such moisture-proof covering. Rubber cables, when subject to electrolysis, can be protected by a covering of water-proof asbestos surrounded by a very heavy braided covering, put tight and thoroughly saturated with compound. In Brooklyn all cables, whether rubber or paper insulation, are covered, wherever they pass through manholes, with heavy asbestos tape. In case a burn-out occurs on a cable with one or two thousand kilowatts behind it, such an arc and heat is developed that injury is apt to result to adjacent cables, and it was found that by protecting each cable in this way further damage has been prevented.

Equipment of Sub-Stations.

The design and equipment of a sub-station in a multiphase system depends almost entirely upon local conditions, as the sub-station contains merely whatever transforming apparatus is necessary to reproduce the energy in the form desired for distribution suited to the local conditions. These transforming devices are commonly as follows:

(1) Static converters and rotary transformers for transformation of multiphase into low-tension direct current; (2) synchronous or induction motors directly connected to arc machines or constant-current transformers, with rectifying commutator for converting multiphase energy into continuous series arc currents; (3) frequency, phase and voltage-changer, when it is desired to change the frequency, phase and voltage, and the transmission current for distribution; (4) constant-current transformers, when it is desired to regulate the multiphase transmission current for use in series alternating arc service.

Records of Efficiency of Transmission and Conversion.

As the efficiencies of these different transformer devices would, no doubt, prove interesting the following data have been collected from the daily records of the Brooklyn system:

(1) Three 150-K-W. static converters and two 200-K-W. rotary transformers, when taken together at three-quarter load, measuring (by wattmeters) the high-tension multiphase energy entering the static converter, and the direct-current, low-tension energy (by wattmeters) leaving the rotary transformers, show an "every-day" efficiency of 84%.

(2) The following is the measured efficiency of an entire sub-station composed of synchronous motors driving arc machines to a capacity of about 1,200 high-tension series arcs:

Total multiphase energy entering the station (by wattmeters) during night run	5,779 K-W. hours.
Series arc energy leaving the station during night run	4,290 " "
Commercial efficiency of sub-station	74.3%
Power-factor	98.2%

With all machines fully loaded, an efficiency of 76% is reached.

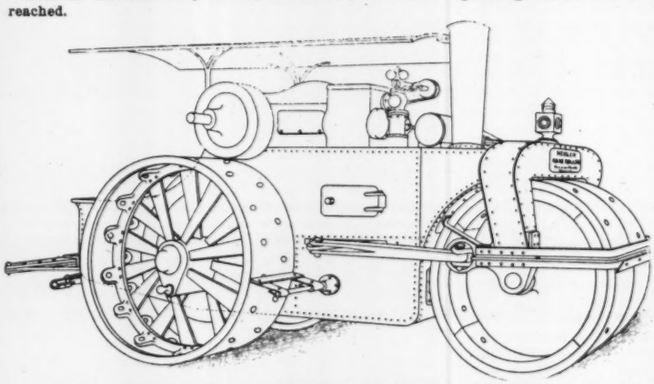


FIG. 1.—PERSPECTIVE SKETCH SHOWING CONSTRUCTION OF HEISLER ROAD ROLLER.
Charles L. Heisler, Erie, Pa., Inventor.

(3) The frequency, phase and voltage-changer, measuring the multiphase energy input and multiphase output, at ¾ load, shows an efficiency of 86%.

(4) The constant-current transformer at full load possesses an efficiency a little under that of the regular static type. At ½ load the efficiency becomes quite low. Owing, however, to the fact that in installations of any size it is always possible to secure about ¾ load, the efficiency in actual practice is about 88%.

The average line loss in Brooklyn from the power station to the sub-stations amounts to 2%, and taking the total energy generated and distributed from the bus-bars in the Union station or generator station and that delivered by the bus-bars in the sub-stations to the distributing system, the loss is 20%, showing an efficiency of the entire system, including loss in transmission and conversion under the different forms of current, of 80%. This does not include the loss on the distributing system from the sub-station to the customers.

These are ordinary operating figures, and are somewhat higher than would be naturally expected, the good results being no doubt due to the high efficiency of the large static transformers (97%) at full load as well as that of the large synchronous motors, and the fact that the operation is so arranged that no transforming apparatus runs at less than ¾ load and averages nearer full load.

The Growth in Size of Electrical Machinery.

The local multiphase transmission system is, in itself, a promoter of consolidations, as well as an economist in energy production. Besides making itself felt in the "everyday" commercial world, it is forcing upon the manufacturing industries new developments in steam and electrical machinery. At the time of the completion of the Brooklyn system, some 18 months ago, a single unit, generating steadily 2,000 K-W. during each hour of the day, was somewhat of a novelty, but now in the same plant will shortly be operated two units of 5,000 HP. each. Yet, it is not the mere increase of the size of the unit that demands careful forethought on the part of the designer and manufacturer, but rather the handling with safety of such units, as new problems of detail, construction and operation are brought forth under these new conditions. The electrical world can well remember when a 500-HP. unit was classed a large venture, but it now already seems as if a 10,000 HP. unit would soon be well under way. The limit of such development seems to be almost entirely in the hands of the engineer and manufacturer, no limits having yet appeared from the business operating standpoint.

A NEW TYPE OF STEAM ROAD ROLLER.

We illustrate in the accompanying cut a steam road roller of a new type, which is being built after designs by Mr. Charles L. Heisler, of Erie, Pa., the inventor of the Heisler geared locomotive. In designing this roller the employment of "back" gears to secure additional purchase for heavy pulling has been abandoned, it being considered that greater tractive power could be obtained in a much better and simpler manner by enlarging the motor engine cylinders. Another modification of the ordinary construction is the mounting of the boiler and the engines and driving mechanism separate from each other, and on a box-shaped steel frame, so constructed that the boiler can be easily removed for repairs. Also, instead of making the front rolls, as is usually done, much smaller than the rear rolls, the two rolls have been made of nearly the same diameter and weight, and are, therefore, of nearly the same efficiency, in compacting the surface over which they pass. This is rendered possible by the construction of the main frame, which transmits the push of the rear rolls directly to the front axle, and thus relieves the king post or yoke swivel from the very heavy stresses which ordinarily come upon it.

The nature of the construction by which these several modifications are secured is shown clearly by Figs. 1 and 2. Fig. 1 shows the box-like main frame, the front yoke, and the side links for steering the front roll. Fig. 2 shows the arrangement of the different parts in more detail. For a 15-ton roller the general dimensions and construction as described for us by the inventor are as follows:

Diameter of the rear rolls	72 ins.
Face of the rear rolls	20 "
Diameter of the front rolls	66 "
Face of the front rolls	23 "
Total width of the roller	76 "
Wheel base from c. to c. of rolls	10 ft. 6 "
Height over all to top of stack	10 " 2 "
Length over all	19 ft.
Diameter of the boiler	28 ins.
Length of the boiler	7 ft.
Length of the firebox	30 ins.
Height of the firebox	42 "
Number of 1¾-in. tubes	75
Length of tubes	48 ins.
Diameter of the two cylinders	9 "
Length of stroke	9 "
Diameter of the crank-shaft	4 "
Diameter of the front and back axles	5 "

The boiler is of the locomotive type with a shell of 5-16-in. flange steel, tube sheets of ⅜-in. flange steel, and the inside door sheet and side walls of 5-16-in. firebox steel. This is carried by the main frame, which is made entirely of heavy sheet steel, and extends between the roller axles. It is made separable at the back roll axle, so as to permit a ready removal of the back rolls with the axle and the pinion shaft and bearings, as well as the boiler, which will slide out clear of the entire machine. The tanks are riveted to the walls of the main frame, which form the sides and bottom of the tanks. The main frame is made extra heavy at the front end where it forms the "goose neck." As already stated, it is so constructed that no stress whatever comes on the boiler from the front rolls, or from the rear driving gear train and rolls. The back tank will clear a curb from 16 to 18 ins.

high. The smokebox is formed by the front end of the main frame, and is fitted with a large door for convenience in cleaning the tubes.

The rolls are of usual construction, except that the front rolls are of practically the same diameter as the rear. They are also made very heavy by means of removable dead weights, to give the same compressing effect as the rear rolls, and to make it unnecessary to go over their path with the rear rolls. A special arrangement is attached to the front roll yoke, so that no abnormal stress whatever can come on the yoke connection. All the stresses or blows caused by climbing an obstacle, or when doing heavy pushing to get out of depressions, will be transmitted directly to the main frame; or rather, from

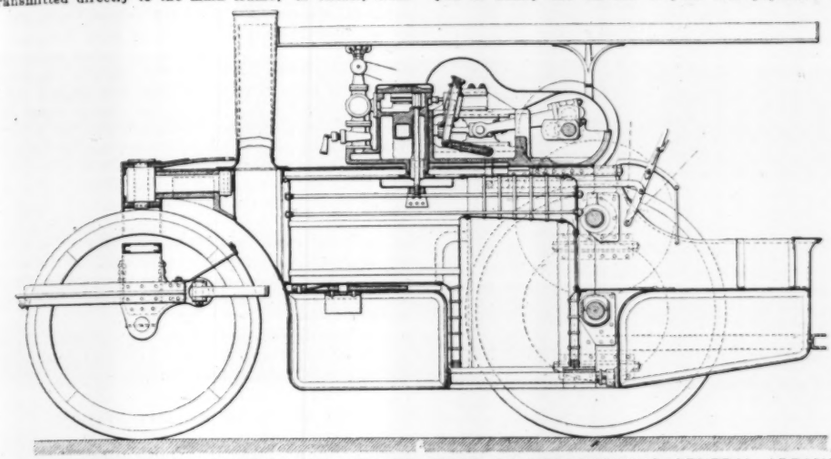


FIG. 2.—SECTIONAL ELEVATION OF HEISLER ROAD ROLLER SHOWING GENERAL ARRANGEMENT OF PARTS AND MACHINERY.

the frame to the roll axle. The steam steering gear is so arranged that the front rolls can be quickly turned to any position, and securely held there without the use of clutches or friction gears. It is independent of the engines, so that the rolls can be turned by the steam gear whether the engines are standing or in motion.

"KALOR;" A NEW FUEL FERTILIZER!

That there are curiosities on the chemical side of engineering, as well as on the purely mechanical side, is well indicated by the following letter recently received from a correspondent:

Sir: We beg to hand you herewith a circular, recently received, regarding a preparation known as "Kalor," which is recommended as a fuel saver; also the printed matter which accompanied it. As we presume that similar circulars were sent to thousands of power users throughout the country, we think that you may deem the matter worthy of investigation, the results of which we shall be pleased to see in your columns. While we are slightly skeptical as to the merits of this and other similar articles, we have never seen a technical account of what it is they do or pretend to do.

Yours very truly,
W. H. Winslow,
Sec'y, Superior Water, Light & Power Co.

West Superior, Wis., April 15, 1899.

The circulars enclosed imparted the information that "Kalor" is a substance which is alleged to increase the heat-producing qualities of fuel. The name is presumably related to the word caloric. It appears to be only a distant relative, however, and from the developments related below we judge it is the black sheep of the family.

The first of these circulars is an imitation typewritten letter, blurred as if from copying, in which in very blue letters the recipient is introduced to "Kalor," and is informed that by treating his fuel with it the coal consumption of his boiler plant can be reduced from 15 to 25%, 90% of his smoke can be abolished, his ashes will be reduced 50%, and his steaming power increased.

Directions for use of the material are given on a small yellow slip, forming one of the documents in evidence, and are to the effect that the material is to be dissolved in water in the proportion of 1 lb. of "Kalor" to 4 gallons of water, and the solution is to be sprinkled over the coal before it is burned. The user is particularly cautioned to reduce the draft while burning the treated fuel.

The imitation typewritten letter above referred to has a printed signature, "The National Fuel Compound Co," and the address upon the letter head is 64 Federal St., Boston, Mass. We quote further from it as follows:

The utility, safety, efficiency and economy of "Kalor" have been fully demonstrated by some of the best engineering experts in the United States and Canada, as set forth in the enclosed circular of testimonials. We have on file the data of many more tests, showing equally good results.

We submit for your consideration the following offer: We will furnish for use in your plant the formula for making "Kalor" (comprising four ingredients, readily obtained at any center, and easily mixed with a shovel or hoe), for the sum of twenty dollars ($20), one-half payable in advance, balance payable after trial of 25 lbs. of "Kalor," which we will furnish you without charge, and which will treat 12 tons of coal, effecting a saving to you of nearly the amount of your first payment. You will be more than satisfied with "Kalor" after you have tested it. If you do not care to bother with the purchase and mixing of the chemicals, we will furnish you with "Kalor" in barrels or bulk for $60 per ton cash, f. o. b. Boston.

The sheet of testimonials accompanying the above letter contains the usual array of stereotyped "since using yours I have used none other" recommendations. It is particularly noticeable that all the letters are without dates, and the names, except one, were unknown to us. The testimonial which heads the list, however, has attached to it the well-known name of Prof. R. C. Carpenter, and reads as follows:

SIBLEY COLLEGE, CORNELL UNIVERSITY.
Ithaca, N. Y.

I send you complete results of four boiler tests made to determine the effect of treating coal with a chemical compound. These four tests represents trials with two kinds of coal; viz., Anthracite Grate and Bituminous Slack. In both cases the conditions of the firing was as nearly identical as possible, except that it was found necessary to maintain somewhat greater draught openings with the coal in its untreated condition. During the tests the same fireman was employed, as he was skilled and accustomed to maintain thin and even fires, as carried throughout the entire tests, it is probable that any accidental effects due to difference in firings were eliminated. The result of the four tests is shown in the accompanying table. I think from all these tests that we have established the fact that by using the compound on dry Anthracites or on Bituminous there is a decided advantage.

R. C. Carpenter,
Professor Experimental Engineering.

The lengthy table of figures following this shows results as follows: Gain on Anthracite 9 per cent., gain on Bituminous Slack 16 per cent.

Naturally the engineer who receives one of these sheets and sees the name of Prof. Carpenter at the head of the list, would be led to place some confidence in the genuineness of the other testimonials, even though the names attached to them were unknown to him and might be purely fictitious.

Upon receipt of these circulars we immediately sent Prof. Carpenter a copy of his alleged testimonial and received the following reply:

Sir: I have never made any tests of "Kalor," and never heard the name until very recently. If any tests of mine are quoted they are either misquoted or have been appropriated bodily from some report or letter describing tests of some other material. Truly yours,

R. C. Carpenter,
Sibley College, Cornell University.

April 25, 1899.

In view of the above letter, it will probably not be difficult for our readers to form a correct opinion of "Kalor," and of the "company" which is offering it to the public. We may add that we tested the "most likely" looking of the testimonials following Prof. Carpenter's, one signed by "R. L. Outwalt, Chief Engineer, the Metropolitan Electric Ry. Co., Toronto, Canada." A letter was sent to that address and has just been returned to us, with the envelope bearing marks which show that diligent search by the post-office officials failed to discover such a person.

This is not the first time that compounds for "doctoring" coal to increase its heating power have been put before the public. One which was exploited to a greater or less extent some years ago rejoiced in the name of "Kem-Kom"; another was known as "C. G. S." This last seems to have been most appropriately named. The mysterious letters doubtless stand for *Cum Grano Salis*, which is a very good motto to remember in considering claims made for any secret chemical compound which is advertised to work wonders.

Since the above was in type we have received another letter from Prof. Carpenter, giving fuller details concerning this unauthorized use of his name as follows:

Sir: My attention has recently been called to the fact that I am represented in an advertising circular as certifying to the excellence of a fuel saving compound called "Kalor," manufactured by the National Fuel Compound Co., of Boston, Mass. The circular claims that I have made a number of tests and found great saving due to its use. I wish to say for the benefit of your readers that I have never made a test of a compound known as "Kalor," nor did I ever hear of the material until the testimonial above referred to was called to my attention by the manager of the Raleigh Electric Co., Raleigh, N. C.

I find on referring to the testimonials in the circular referred to that a letter of mine is published which has no reference to "Kalor," but did have reference to another compound which at the time was called "S. C. (394) Compound." The writer was engaged by a disinterested third person to make a series of boiler tests during the year 1892 with and without the latter compound in such a manner as to determine its value, and was requested to write a third person the results of the tests as made from time to time.

The letter published is a copy of one written during the progress of the trials for information of said third person, and the tests to which it refers were those in progress at the time. It will be noted by referring to the letter that the trials quoted did show an apparent, although slight, advantage due to using the compound. The compound was applied by putting it in solution and applying it to the coal. Mr. Wm. Kent suggested that the apparent gain might be due entirely to the dampening of the coal when applying the compound. Subsequently other trials were made, and it was found that equally as good results could be obtained by slightly dampening the coal without the use of "S. C. (394) Compound" as with it. The final conclusions of our entire series of trials was that the compound S. C. (394) was absolutely worthless as a fuel; further, that all the gain which was caused by its use in some cases was due to the applied water or to the method of handling the fire. This final conclusion I see is not given in the testimonial, but on the contrary a letter is published to a third party which merely showed the results at a time before the investigation was completed. I might add, as showing the character of the men who represented the "S. C. (394) Compound," that they never settled any bill for the investigation, nor have we been able to learn that they were in financial condition to settle such bill since that time.

The writer knows nothing in regard to "Kalor," nor does he know anything in relation to the National Fuel Compound Co., but he does know that the letter in question was never written for the purpose for which it was used and consequently that its use in such a manner must tend to deceive the public. If the compound is the same as the compound investigated in 1892, the writer does not hesitate to say that he believes it entirely worthless as a means of improving the calorific value of fuel.

Very truly yours,
R. C. Carpenter.

Ithaca, N. Y., May 26, 1899.

THE IMPROVEMENT OF BAYOU LAFOURCHE, says the Lafourche and Achafalaya levee boards at their last meeting, demands the construction of a lock at the entrance from the Mississippi at Donaldsonville, and Congress will be asked to make an appropriation for this purpose. Owing to the high level of the late floods the levees would have to be raised several feet along the bayou and this is beyond the means of the two levee districts. Since April, 1890, 7,250,000 cu. yds. of levees have been built at a cost of $1,010,000, and the results are negative and crevasses still occur. The lock at Donaldsonville, say the boards, would do away with the maintenance of levees on 170 miles of bayou. The lock was recommended by the U. S. Engineers 13 years ago, but the plan was then opposed by planters on the lower Lafourche, who feared that the water in the bayou would become too brackish from salt water if the river were shut out; it is now denied that there is any such danger to rice culture.

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ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page XIX. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.

We give considerable space in this issue to a paper by Mr. W. S. Barstow, describing the great plant for the generation and distribution of electric current from a central station which has been built up in Brooklyn under Mr. Barstow's direction. A notable feature of the paper is its account of the difficult requirements which steam engine builders are now called on to meet in the design of engines to drive the modern huge alternating current generators for electric stations. These great machines are now operated in multiple; and when so connected any variation in the action of the engines driving them results in a surge of current from one generator to the other. An intricate study of the action of steam on the pistons, of the momentum of the fly-wheel and other moving masses, and of all forces that tend to accelerate or retard the speed, appears to be necessary on the part of the designer to reduce this current flow between the machines to a minimum.

This fact is of interest in connection with the action just taken by the American Society of Mechanical Engineers looking to the adoption of standard sizes for direct-connected generators. When the design of the engine is a matter of such extreme care, the advantage of standard sizes in enabling the designer to adjust his work by the results of experience is obvious.

A curious proposition for the bridging of the East River has been made by Admiral Melville. He starts out with the statement that the East River is now so much obstructed by "the obsolete and obnoxious ferry-boat," that its navigation is attended with difficulty and danger, and he proposes the following as a remedy:

> I would suggest a system which has been of necessity, but with success, applied in at least two of the most crowded ports of the world. I refer to the method of connecting by low bridges on piers, practically at grade, but sufficiently high in all spans or the central span only for the tugboats and barges in which nearly all of the harbor commerce is now conducted. The central span should be, as well, of the cantilever type, folding back on abutments, to permit the passage of the largest vessels. I would propose a dozen or more of these low bridges across the river, as many as need be for the freest communication between the foot of Wall St. and the opposite shore, in the most direct line, and continuing all the way up the East River to or beyond Blackwell's Island. In fact, make in time the connection of every main street in either city with the corresponding street on the opposite shore. There would be thus a real and true welding of the cities physically as well as in theory and name.

We fear that the vessels which are now obstructed by the "obnoxious ferry-boats" would find many times greater difficulty in threading their way through such a labyrinth of bridges and draw-spans openings as is here proposed. As for the traffic passing across these bridges, it would probably be blocked three-quarters of the time by open draws. Again, it appears to be the idea that such low-level bridges would be inexpensive structures compared with the present suspension bridges completed and building. It is by no means certain that this would be the case. A very large proportion of the cost of the present bridges is the piers, which have to be sunk to a depth of 100 ft. or more. Clearly little saving could be made by increasing the number of piers beyond three, to divide the structure into two spans. The proposed plan, however, would require at least four piers, two of them to be sunk adjacent to the central channel, a job which in itself would tax all the resources of engineering.

The Admiral's proposition, however, has at least one element in it which deserves consideration. If it is true that the navigation interests may some time consent to a low level bridge over the East River, they should begin by permitting the Long Island R. R. to build such a structure at Blackwell's Island. A bridge 60 to 70 ft. in height here would clear all ordinary traffic and would furnish access for the Long Island R. R. to Manhattan Island, within reasonable limits of expense, and with practicable grades upon the approaches. At any lower point of the river, however, the principle of keeping the street and the river traffic on different levels is the correct one for the future, as well as the present.

Attention is again called to the necessity of using more care in laying sewer pipes in wet ground, especially outlet sewers to purification works. The latest case in point is Westboro, Mass., as noted briefly elsewhere in this issue. The filter beds at Westboro, which by the way were insufficient in area and otherwise unsuited for the normal sewage flow, have been drowned out by ground water in excess of the sewage proper, besides which the influx of ground water gives rise to a fungous growth in the outlet sewer. Accounts of this trouble follow closely upon a similar experience with ground water, but without the fungous growth, at Plainfield, N. J., described in our issue of March 16, 1899. One has only to read a few reports of conservative engineers on the necessary capacity of separate sanitary sewerage systems to see how important a factor infiltration is, even where purification of sewage is not proposed. It should be remembered that scores of cities whose sewerage systems are designed without thought of purification, must come to it in a few years, and care to make tight joints should be exercised accordingly. Where ground water reaches the sewers beyond all estimates, as has been observed in a number of instances, it means that the sewers will not be able to perform the ultimate service for which they were intended. The principal cases already noted have been in connection with purification works, or some special matter to bring them forward. Doubtless for every one of these cases there are ten others, where infiltration is going on unheeded as yet, because there has been no occasion to observe it. But the day of reckoning will come, with the natural growth of population.

The "multiple energizer momentum" engine, which was exposed in our issue of April 1, 1897, has bobbed up again, this time in Philadelphia. The New York "Herald," of May 21, devotes a column to illustration and description of this "New Power Economizer." As many of our readers will recall, this is the scheme in which an automatic clutch operates to disconnect the engine from its fly-wheel as it approaches the end of a stroke and connect it again as it approaches midstroke, the object of all this being "to utilize the momentum of the fly-wheel to do the work," or, as the "Herald" expresses it:

> By means of this amazing device the engine never works directly upon the load, as all the burden it is required to carry is the fly-wheel.

The reporter also explains that this invention utilizes "Nature's own power—the power which she has used for ages in the spinning of the globe upon its axis," and he uses much other similar twaddle to deceive the readers into the belief that he is describing a real and notable invention instead of a common, ordinary out-and-out perpetual motion machine swindle in thin disguise.

The fact is, of course, as we presume many of our readers have discovered for themselves, that this is just the sort of thing most newspapers prefer to describe. The bigger the claims made by the promoter, the better. A crank who has a machine to turn the world backward on its axis is good material for copy, and the publicity that the fake schemes obtain in this way assists them in selling stock to the credulous public.

It is not without interest to note in this connection a report which comes to us that the "Power Multiplying Engine Co." of Philadelphia, a compressed air scheme which was exposed in our issue of April 6, has had its furniture and other effects sold by the sheriff. Apparently the company failed to "raise the wind," notwithstanding its alleged utilization of compressed air.

THE DESIGN OF RAILWAY STATIONS.

II.

As noted in our former editorial article on this subject, in our issue of Jan. 12, the usual practice in this country is to have one large general waiting room, with another room for women. In some few cases separate rooms are allotted for main line and suburban passengers. In Europe, separate rooms have to be provided for passengers of the different classes, and in the St. Lazare terminal station of the Western Ry., at Paris, the subdivision of waiting rooms is carried to an extreme that is not to be recommended. In the headhouse there is a row of small waiting rooms for passengers by the various suburban lines, all the rooms opening upon the broad platform between the headhouse and the tracks.

At small stations there is often but one waiting room, and even at larger stations, where a women's waiting room is provided, men accompanied by women have access to this room. In all cases, therefore, where the provision can be made, there should be private accommodations for women who are invalids or who wish to rest undisturbed, and at large stations this sometimes takes the form of a comfortable parlor. It is a common practice to have the men's toilet room open into the main waiting room, but a better plan is to have the toilet room open upon a corridor or upon the main platform, where any odors from it will be dissipated in the open air. The plan of making the toilet room accessible only from the smoking room is also objectionable. The two rooms should be entirely independent of each other and of the waiting room.

Passengers should not be confined entirely to the waiting rooms by gates, as is sometimes done, but should at least have access to the main platform, so as to distribute the crowd and make waiting for trains in hot weather less trying. A portion of this platform may be fenced off to prevent access to the trains except through guarded gates.

This brings up the much-mooted question as to the extent to which passengers going to trains should be stopped for ticket inspection. Practice varies very greatly in this. Some railway stations are a byword among travelers for the extent to which access to the trains is hindered, while in others little or no attempt is made to inspect tickets. In general, it can be said that in handling heavy suburban traffic, the best practice is to have no restrictions whatever upon the movement of passengers to their trains, beyond keeping the gates closed until the train is ready. For passengers taking through express trains, however, inspection of tickets is a necessary precaution.

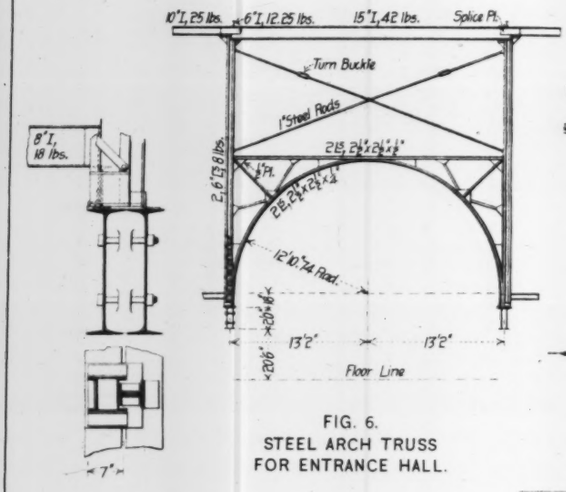


FIG. 6.
STEEL ARCH TRUSS
FOR ENTRANCE HALL.

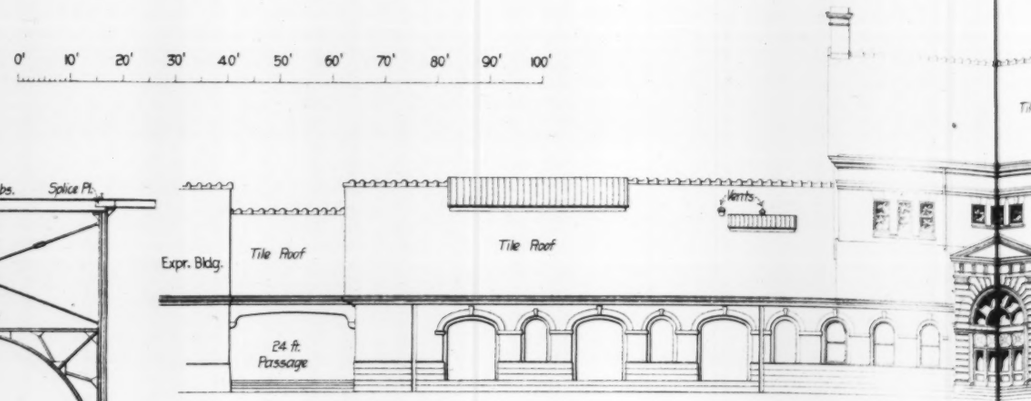


FIG. 3. SIDE ELEVATION (C

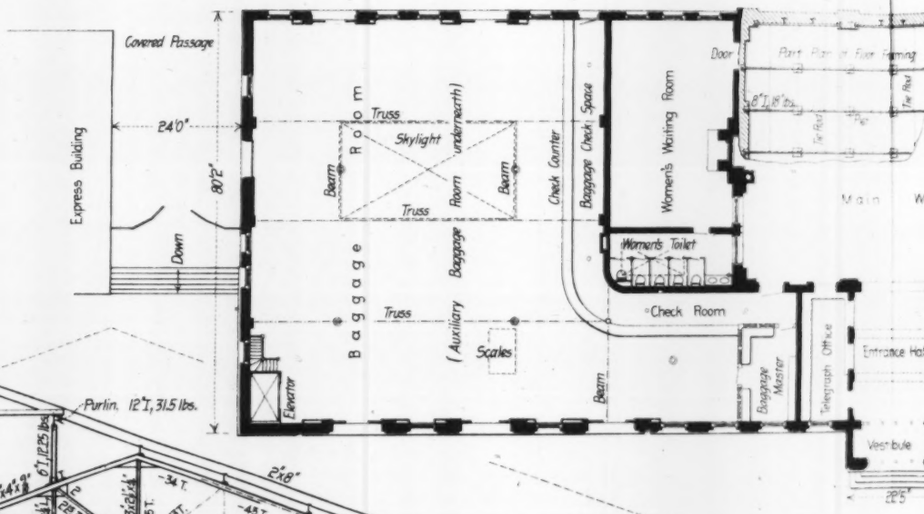


FIG. 5. PLAN OF

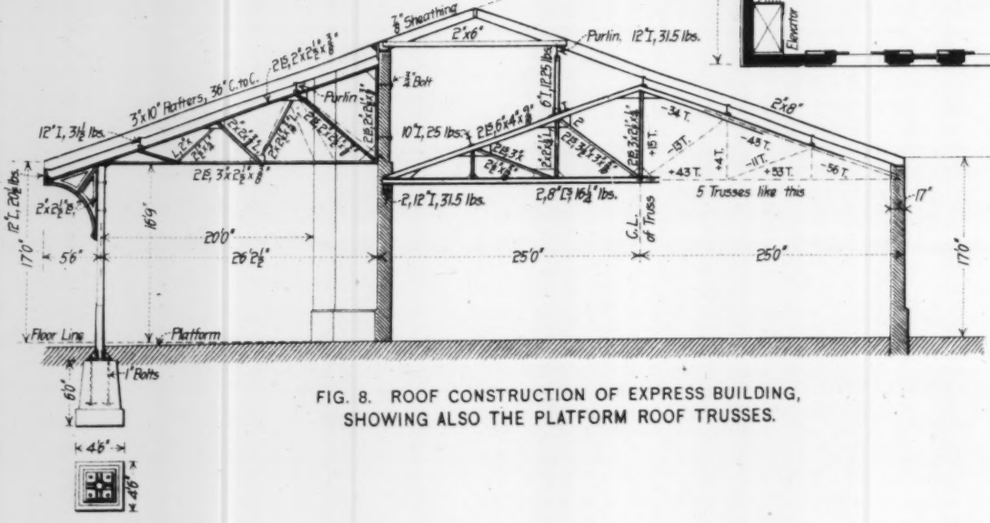
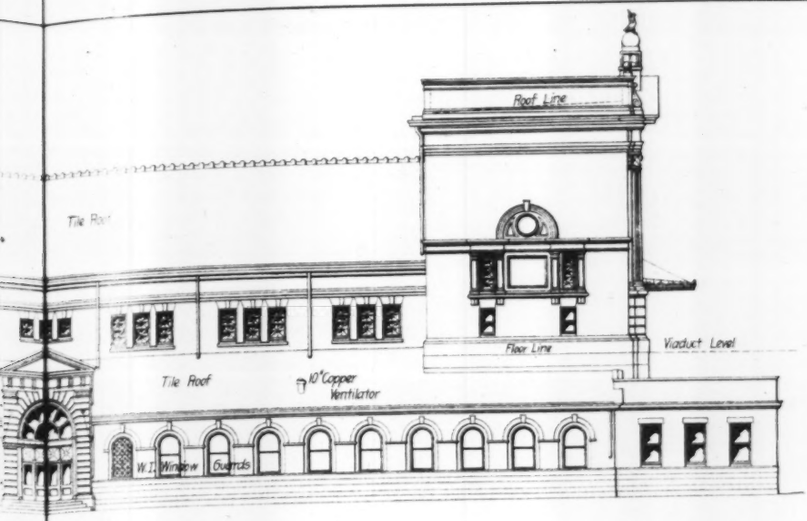


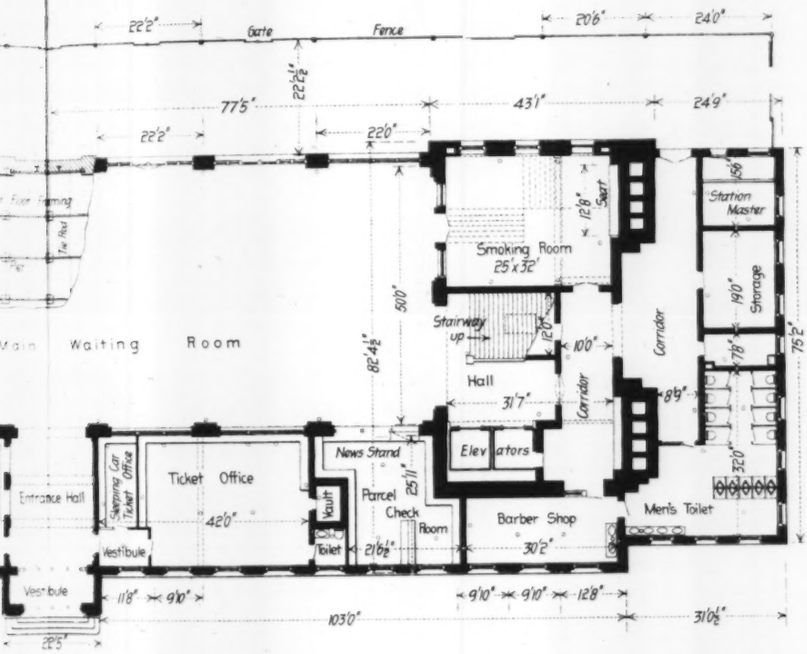
FIG. 8. ROOF CONSTRUCTION OF EXPRESS BUILDING,
SHOWING ALSO THE PLATFORM ROOF TRUSSES.

NEW UNION RAILWAY STATI

Frost & Granger, Architects. J. B. Ber



LEVATION (CITY SIDE.)



PLAN OF LOWER FLOOR.

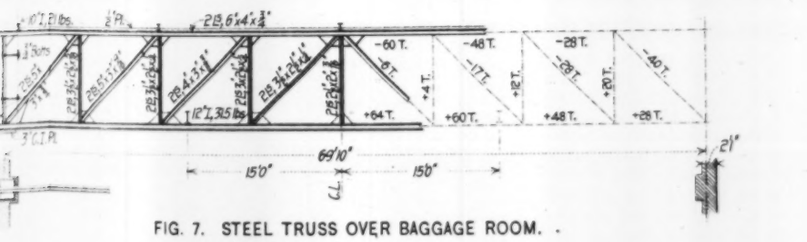


FIG. 7. STEEL TRUSS OVER BAGGAGE ROOM.

FIG. 2. END ELEVATION
(AT VIADUCT LEVEL.)

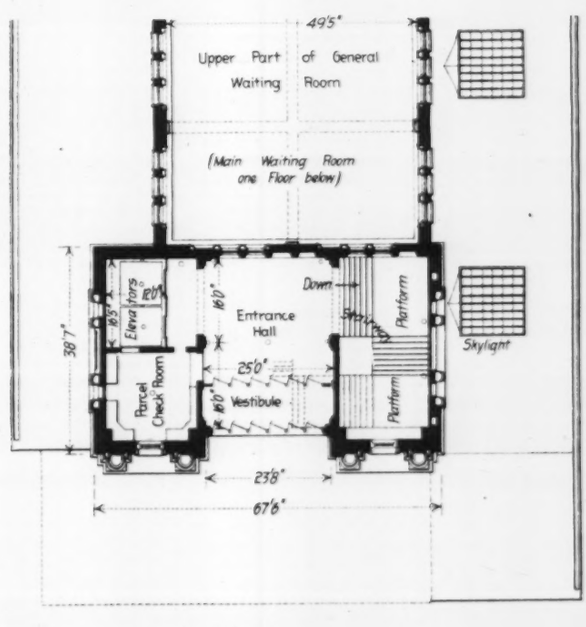


FIG. 4.
PART PLAN OF UPPER FLOOR.

Y STATION AT OMAHA, NEB.

J. B. Berry, Chief Engineer, Union Pacific Ry.

CHAS. HART, LITH., 30 VESEY ST., N. Y.

Seats on the platforms will relieve the waiting rooms from much passing to and fro, especially in fine weather. At large stations a separate waiting room for hackmen and omnibus men is an excellent plan, either inside the building or separate from it. This will afford accommodation for men who must necessarily pass a good deal of time at the station, but will check them from lounging about the entrances or platforms.

The business of the station may be much facilitated and confusion prevented by properly locating the ticket office, and providing a sufficient number of windows for use in an emergency. This is not unfrequently overlooked, however, and even large stations have sometimes but a single ticket window, and that in the main waiting room. The north-end union station in Boston is a good example in this respect, having ticket windows in the waiting-room and in the passage way or corridor which leads directly from the street to the platform. On the other hand, the Duluth terminal of the Chicago, St. Paul, Minneapolis & Omaha Ry. affords an example of faulty arrangement. The ticket office serves to divide the waiting room into two parts, and has the window in the narrow space connecting the two parts, and directly opposite the main entrance. At busy times persons going in or out, or passing from one room to another, will interfere more or less with the line of people at the window. At the same time the ticket clerk will be directly exposed to the draft from the open doors. In the description of this station in our issue of Feb. 10, 1898, it was pointed out that these objections might easily have been avoided in several ways.

There should be ample room for the agent's ticket racks, desk, books, etc. At stations where the ticket agent is also station agent and telegraph operator, it is usual to have a bay window on the track side of the office, so as to afford a view of train movements, etc., and care should be taken that this view is not obstructed. In one case to which our attention has been called, a clock tower and a baggage room project beyond the outer line of the bay window, shutting off the view in both directions. In this case convenience and service requirements were subordinated to the architectural design, with the result of causing daily exasperation and annoyance to the agent.

Care should be taken to have ample space and a good location for the baggage and express rooms, convenient for the handling of baggage and express matter between these rooms and the wagons and trains. In large stations the baggage checking room should be easy of access from the ticket office or main hall, as in the new union station at Omaha. Baggage lifts and conveyors are very desirable additions to the equipment. The former are frequently used and the latter occasionally, as at the Grand Central Station in New York city (Eng. News, Jan. 6, 1898).

If possible, it is well to have baggage platforms independent of the passenger platforms. This may be done where the station has a series of single tracks and platforms, by using alternate platforms for passengers and baggage, respectively. At the Polk St. terminal station in Chicago, where the baggage room is at the side of the train shed, the baggage is not conveyed on trucks between the cars and the baggage room. For outgoing trains, the baggage cars are loaded at the platform alongside the baggage room, and are switched out and attached to the train just before the time for starting. For incoming trains, after the passengers have all left the cars the train is backed out, and the baggage cars are switched up to the baggage room. This arrangement involves extra switching and coupling, etc., just at the last moment, and causes considerable delay for incoming passengers who wish to claim their baggage.

In the interior finish of new stations, as in the finish of "palace" cars, there is too frequently a tendency to unnecessary and lavish expenditure for elaborate decorative treatment, even to the extent of interfering with the proper purposes of the station. Ample light and space, convenience of access to the various rooms used by passengers, proper heating and ventilating, and comfortable accommodations, are of much more importance than mere showiness or elaborate decoration. In the main waiting-rooms, especially, spaciousness and light are to be aimed at, and it is a mistake to use small or fanciful windows in such rooms. For lighting, the ordinary open arc lamps are rarely satisfactory, on account of the black shadows which they throw, and the movement of these shadows if the lamps are so hung as to swing. Enclosed arc lamps are much better, giving a steadier and more diffused light and requiring less attention. The interior lighting should be by incandescent lamps, perhaps supplemented by a few arc lights in the larger rooms.

Any underground passages or rooms should be carefully designed for efficient lighting, drainage and ventilation, and should be kept scrupulously clean. Inclined ways are superior to steps and elevators in convenience and in effecting rapid entrance or exit, and in many cases such inclines can be provided by proper design. They are inadmissible, however, in any place exposed to the weather. Stairways should be wide, with easy steps, and should be fitted with hand rails. If they are very wide a central hand rail may be added. The pitch should not be steep, nor should the flights be too long. Where passenger elevators are used, the cars must be of large capacity if they are to be of any real service. They must in any case be supplemented by ample stairways, as they cannot deal with a rush of passengers at train time, especially where there is a heavy suburban traffic.

Woodwork should be used as little as possible in the interior finish, particularly in the smoking and toilet rooms. In the latter, the partitions should not reach within 10 or 12 ins. of the floor, so as to have no corners for dust and damp to collect, and leaving room for a brush or mop to clean the entire floor.

Platforms and Train Sheds.

Platforms for incoming trains should be of ample width to allow for the quick dispersion of the crowd of passengers without confusion. Longitudinal platforms between tracks are often too narrow for convenience, or even safety, especially when baggage trucks are hauled along the platforms. The minimum width for such platforms should be about 12 ft., while a width of 18 to 20 ft. is better if it can be provided, especially where there is a line of columns on the platform. As already noted, it is well to arrange separate platforms for baggage trucking at terminals. The new southern terminal station at Boston, with 28 stub tracks, has seven platforms exclusively for baggage, the trucks being raised and lowered by elevators connecting with a subway which runs under the station from the inbound baggage room on one side to the outbound baggage room on the other side.

The main platform in front of a side-house should be from 20 to 30 ft. wide, and the transverse platform at a terminal station from 30 to 75 ft. wide. The St. Louis union station has a 50-ft. transverse platform, with longitudinal platforms 22 ft. 6 ins. wide, and the new Pennsylvania R. R. station at Pittsburg will have 20-ft. longitudinal platforms running from a transverse platform 85 ft. wide. The latter has 50 ft. of its width fenced off so as to be available to the public, leaving 35 ft. between the fence and the ends of the tracks. Some English terminals have two tracks specially for main line incoming trains, separated by a broad platform with a carriageway. In one such case a 70-ft. platform has two 20-ft. sidewalks and a 30-ft. roadway, sufficient for two lines of cabs. Platforms should be from 6 to 12 ins. above the rails, and within easy reach of the lowest steps of day cars. The practice of flooring the whole space in front of the station with planks is not to be recommended, as it encourages passengers to walk upon the tracks. It is much better to have regular platforms between the tracks, connected by transverse platforms of convenient width. At terminal stations, the public should not have free access to the longitudinal platforms for outgoing trains, but the platforms for incoming trains are usually left open, unless they are so narrow as to be inconvenient.

At through stations it very often happens that a crowd will collect on the tracks ready to take a local or excursion train, and may not get out of the way in time for the passage of a fast through train. On some roads the through trains must slow down for a station where another train is standing, thus incurring delay and inconvenience in the train service.

The Massachusetts State Railroad Commission, in its report for 1889, called attention to the liability to accidents of this kind, and urged that bridges or subways should be provided at the important local stations within 12 miles of Boston. To this report was appended a paper by Prof. Goering, Professor of Railway Engineering at the Berlin Polytechnic, describing the law and practice in Germany in this respect. In Germany there had been a great deal of trouble of this kind, and public attention was directed to the matter by a terrible accident at Steglitz, on Sept. 2, 1883, the day being a public holiday. This station had a low fence, with four gates, in the middle of the four tracks, with a grade crossing at the ends of the platforms. About 10 p. m. a local train from Berlin stopped at the station, a crowd then waiting on the opposite platform. Instead of going round by the grade crossing (which was protected by gates), the crowd swarmed across the tracks, intending to enter the cars from the wrong side. Some climbed over the fence and others opened the gates, in spite of the warning shouts of the station men. An express train from Berlin came up at this moment and dashed through the crowd, killing 37 people and injuring many more. This accident silenced the opposition that had been made to bridges and subways, on the ground of the expense, and since that time close and high fences, with subways or bridges, have been built at all stations near Berlin.

In this country the public makes great objection to such safety precautions, and generally considers that it has an inalienable right to cross or walk upon the tracks, with an equal right to sue the railway for damages when accidents ensue from this practice. The precautionary measures should, however, be provided and their use enforced, in the interests of the public and the passengers. In Europe, very rigid laws and regulations prohibiting this kind of trespassing are very strictly enforced, and it is to be wished that such regulations could be introduced in this country. Where the express tracks are fenced off, or when a fence is placed between the tracks of a double track line, it should be of such design and height as to check foolhardy attempts to climb over it, while the service gates for the employees should be kept locked.

In Europe, bridges are usually preferred to subways, but the latter have the advantage of requiring shorter flights of steps, especially if a flat roof of I-beams and brick or concrete arches is used. They also afford better protection in bad weather. A bridge must usually have its floor at least 15 ft. above the tracks, while the floor of a subway may be but 10 ft. below them. The subways should be as short and as easy of access as possible, and should be specially well lighted, ventilated and drained. An example of waterproof construction for a station subway was given in our issue of March 25, 1897.

With an elevated station, a subway at or above street level can easily be provided, while a bridge can be provided at a station or a cut. On the depressed tracks of the Harlem Division of the New York Central R. R., the stations span the tracks, and have stairways to the side platforms, the middle (express) tracks being fenced in. Where the main floor is above the track level, as in the new Burlington station at Omaha, a bridge over the tracks might well be provided, having stairways to the island platforms. This plan is followed in the Toronto union station.

An important consideration in the design of all large stations is that of the shelter to be provided over the platforms. If a train-shed is decided upon, covering tracks and platforms, it may be designed on either of two plans: (1) It may be a great arched structure spanning the entire width of the space covered, like the Philadelphia & Reading R. R. and Pensylvania R. R. stations at Philadelphia, the Grand Central Station in New York, or the Grand Central Station in Chicago; (2) it may be made up of a series of shorter spans, supported by intermediate columns, as in the Providence station, the St. Louis union station, or the Boston union stations. The large arched

train-shed is imposing in appearance, but is costly to build and maintain, difficult to light satisfactorily, and difficult to be made comfortable. The St. Louis station has an umbrella roof with a low flat curve, the roof being 601 ft. wide, 21 ft. high at the sides, and 75 ft. to the top of the main truss at the middle. The end screens come down to within 28 ft. of the track at the highest point. Open-sided train sheds, like that of the Illinois Central R. R. at Chicago, are very uncomfortable in bad weather, and if the station plan does not provide for buildings along the sides of the train-sheds, then the sides should be enclosed by walls with ample window space. Where columns are used to support the roof, it is usually better to place them in the middle of the platforms rather than between the tracks, as they thus leave the track space unobstructed, are less likely to be struck by derailed cars or engines, and are less likely to cause accidents by passengers or employees jumping from trains and striking them.

If separate roofs are adopted for the several platforms, a broad transverse roof should connect them to the station roof at one end, so that passengers may go to and from the trains under shelter. Platform roofs are frequently so high and narrow as to afford but little protection from the rain. A plan we have seen used in England at a through station having four tracks between the platforms, is to extend the platform roof over the nearest track, supporting it by columns on the outside. This keeps the platform well protected, and prevents the dropping of water upon passengers entering or alighting from the cars. At through stations, the main platform, next the side-house, can also be protected to some extent from the sweep of the wind and rain by extending walls from the station building partly across its ends. This arrangement should, of course, be included in the architectural design of the station building.

The track plan is a very important consideration in station design, in order to provide ample facilities for train service, and to ensure the prompt handling of the traffic, especially in an emergency, as at times of exceptional press of traffic. The amount of track required and its arrangement, will, of course, depend upon the amount and requirements of the traffic. Stub-end tracks should generally be in pairs, with cross-overs near the ends, so that the engine of an incoming train can be got out without waiting for its train. This is specially important where suburban traffic has to be provided for. With an isolated stub track, the engine must wait idle until the train is hauled out. With a double track, however, the engine can be switched onto the adjacent track and run out to the water crane or coaling station, or onto a siding ready to take out another train. Turntables are used extensively for this purpose in Europe, where engines and cars having a short wheel-base have been almost universally used until rather reecnt years. At the Chicago Union Station, proposed by the late Gen. Torrence, in 1892, a transfer table was to be placed at the end of each pair of tracks to facilitate the movements of engines and cars.

Station tracks and platforms should not be built on curves, if it is possible to avoid such an arrangement, as it is inconvenient and dangerous for the passengers and the station staff, and makes it difficult for the conductor or the air-brake inspectors to signal the engineman on a train engine, or on an engine which is making up a train.

Running into the bumpers is a somewhat frequent class of accident at stub-end tracks, and high bumping blocks of great resisting power are to be preferred to the low wheel-guards sometimes provided. Some English terminal stations have the bumpers fitted with long stroke hydraulic buffers, which have prevented many accidents. The station at Dresden (Germany) has a sand track just in advance of the bumpers, the sand covering the rails and forming a resistance to the wheels. This, however, necessitates an extra length of track, as trains must normally stop before reaching the sanded section.

In conclusion, we append an alphabetical list of some of the principal stations which have been illustrated and described in our columns during the present decade.

Railway Stations Described in Engineering News.

Battle Creek, Mich., Sept. 24, Oct. 2, 1897.
Bay City, Mich. (Mich. Cen. R.R.), Dec. 27, 1890.
Beaver, Pa.; P. & L. E. R. R., Jan. 12, 1899.
Berlin, Germany; Oct. 6, 1898.
Boston, elevated railway, March 31, 1898.
Boston, southern union station, Jan. 14 and July 8, 1897; March 24, 1898.
Boston, subway, Feb. 3, 1898.
Brockton, Mass., March 25, 1897.
Brooklyn, Brooklyn Bridge, Feb. 9 and April 20, 1893.
Brooklyn Bridge, Feb. 9 and April 20, 1893; Nov. 8, 1894.
Cheyenne, Wyo. (Union Pacific Ry.), April 2, 1887.
Chicago, Columbian Exhibition terminal, Oct. 13, 1892.
" Illinois Central R. R., April 28, 1892.
" Intramural Elec. Elev. Ry., Oct. 20, 1892.
" proposed union station, Feb. 8, 1890; May 5, 1892.
" South Side Elevated R. R., Jan. 16, 1892.
Cologne, Germany, Oct. 6, 1892.
Detroit, Mich.; Fort St. union station, Jan. 31, 1891.
Duluth, Minn.; C., St. P., M. & O. Ry., Feb. 10, 1898.
Elevated Railways: Chicago and Boston, Jan. 16, 1892; March 31, 1898.
Fort Payne, Ala.; Ala. G. S. Ry., Sept. 12, 1891.
Jersey City; C. R. R. of N. J., Oct. 6, 1888.
" Erie R. R., May 29, 1886.
" Pennsylvania R. R., Dec. 27, 1890; Sept. 26, and Oct. 3, 1891.
Lahore, India, Sept. 1, 1892.
London; L. & S.W.Ry. (Waterloo Station), June 23, 1892.
London, underground, Nov. 3, 1898.
Louisville, Ky.; L. & N. R. R., July 25, 1891.
Macon & Birmingham Ry., small stations, May 26, 1892.
Milwaukee, Wis.; C., M. & St. P. Ry., March 5, 1887.
Montgomery, Ala.; L. & N. R. R., Aug. 19, 1897.
Montreal, Can.; Can. Pacific Ry. (Dalhousie Square), Dec. 31, 1896.
Montreal, Can.; Can. Pacific Ry. (Windsor Square), March 3 and 17, 1888.
Nashville, Tenn.; L. & N. R. R., June 22, 1893.
Newark, N. J.; Pennsylvania R. R., Feb. 14, 1891.
New Orleans, La.; Ill. Central R. R., Dec. 1, 1892.
New York; Brooklyn Bridge, Nov. 8, 1894.
" Grand Central Station, Jan. 6, 1898.
" 125th Street, May 25, 1893.
" Overhead stations on Harlem line, Feb. 8 and 15, 1890.
" West Shore R.R., Sept. 29, 1883; Nov. 21, 1891.
Omaha, Neb.; Union Station, Aug. 17, 1889.
Philadelphia, Pennsylvania R. R., Oct. 6 and 13, 1892; June 1 and 8, 1893.
Philadelphia, Phila. & Read R. R., Jan. 19, Feb. 2, 1893.
Pittsburg, Pa.; Pennsylvania R. R., Nov. 17, 1898.
Quincy, Ill.; C., B. & Q. R. R., Feb. 16, 1899.
Providence, R. I., union station, Jan. 28, 1897; Aug. 2, 1890, and April 27, 1889.
St. Louis, union station, Oct. 3, 1891; April 2, 21, and 28, 1892.
Springfield, Ill.; C. & A. R. R., Jan. 16, 1896.
Stockbridge, Mass.; N.Y., N.H. & H. R.R., Nov. 30, 1893.
Suburban designs, Aug. 4, and 25, 1888.
Toronto, Ont.; union station, Dec. 27, 1894.
Weehawken, N. Y.; West Shore R. R., Sept. 29, 1883.
West Shore Ry.; standard plans, March 31, 1888.

LETTERS TO THE EDITOR.

Block Signaling and Interlocking; C., St. P., M. & O. Ry. —Correction.

Sir: In the diagram of signals and signal indications on the Chicago, St. Paul, Minneapolis & Omaha Ry., on p. 326 of your issue of May 25, a wrong impression is given by the note that a white circle means "white." It simply means that it is "blank," showing no light at all. White is not used at all as a signal light. Thus, in Fig. 3, your explanation of symbols makes it appear that the "clear" indication is given by a green and a white light, whereas in fact only a green light is shown.

This is properly described in the article, but the illustration gives a wrong impression. Yours truly,

Chicago, Ill., May 27, 1899. C. O. D.

Felling Timber in the Tropics During the Waning Moon.

Sir: In your issue of May 11, I note an abstract from a paper read by Mr. Earnest R. Woakes, before the American Institute of Mining Engineers, the item quoted relating to the necessity, in the tropics, of felling timber during the waning moon. I can entirely corroborate Mr. Woakes' statements in this connection, and I am all the more glad to do so, because he is an old friend, as I happened to be for several years engaged in engineering work near him, in Colombia, South America.

It was an absolutely invariable rule there, that all timber should be felled in menguante, or during the waning of the moon. The creciente, or the period of the moon's increase, was employed in sawing the felled timber, all work having to be done by hand, with a pit saw. I have repeatedly tested the effect of the tropical moon on timber. On one occasion, in building a fence of the native bamboo, I had all the bamboo cut from the same thicket, and felled it all, except enough for one panel, during the waning moon. This one panel, which was cut while the moon was waxing, turned black in a few days, and had begun to rot in less than six weeks. The rest of the fence grew white and hard, and was in perfect condition when last I saw it, some three years after it was built. In making clearings for mining work, I have frequently noticed the rise and fall of the sap in the stumps of the felled trees, and have observed the sap to continue during each creciente to run out of the pores on the top of the stump and down the sides of the stump, for several months after the tree had been felled. During menguante, the same stump would be dry.

Dabney H. Maury, Jr.,
Engineer and Superintendent, Peoria Water Works Co.
Peoria, Ill., May 23, 1899.

The Magdalena River Cantilever Bridge at Honda, Colombia.

Sir: I have read with much interest the letter in your issue of Feb. 2 from Mr. H. S. Wood, the designing engineer of the cantilever bridge over the Magdalena River at Honda. As manager of one of the principal transportation lines in this country, including railway and river steamboats, from Cartagena up to and beyond Honda, on the Magdalena River, I am naturally very much interested in this bridge, and have seen it in various stages of construction and walked over it after completion.

It is certainly a very fine, or rather "fine drawn" bridge, but I am inclined to believe that Mr. Wood's assumption that a train of pack mules is the heaviest load likely to cross the bridge is a little unsafe. Whole regiments of soldiers will frequently have to pass over it, and although it is customary to give the order for troops in crossing a bridge of that kind to "break step," yet I could well have wished that Mr. Wood had adopted a little greater factor of safety than 500 lbs. per lin. ft.

A close pack of troops who might not obey the order to break step, marching across the Honda bridge, or a crowd and stampede, is not a pleasant possibility to contemplate, and I for one am glad that I am aware of it, for the operation of hauling our steamboats over the "Salto" (or Falls) at Honda is a very interesting sight, and I have frequently seen both banks of the river crowded with people witnessing it before the bridge was completed, and as the bridge is now undoubtedly the best spot from which to view the sight, I am quite sure that during carnival times and other "fiestas," of which the South Americans are so fond, there may often be a solid pack of people on the Honda Bridge to witness steamboats shooting the falls or being hauled up, or to view the fireworks, etc. I certainly shall not be one of the crowd, knowing the bridge now to have been calculated for only 500 lbs. "live load" to the lineal foot. I thought the bridge looked very light when I saw it, but had not taken the pains to examine the plans that Mr. Navarro has. I am indeed sorry, however, that poor Mr. Navarro's want of technical knowledge has been so treated, and that Mr. Cooper's or any other standard specifications for highway bridges have been disregarded in the designs for this bridge to such an injudicious degree. Mr. H. S. Wood may yet have to record another chapter in the "amusing" history of the Honda Bridge.

Yours very truly, J. T. Ford,
Assoc. M. Inst. C. E., Chief Engineer and General Manager Cartagena-Magdalena Ry. and Fluvial Co.
Cartagena, Colombia, Feb. 13, 1899.

(According to our usual rule, we submitted a proof of the above letter to Mr. Wood, who has sent us the following letter in reply.—Ed.)

Sir: In rejoinder to the letter of Mr. J. T. Ford, criticising the Magdalena River bridge built by us at Honda, Colombia, we will merely state that a railway engineer is apt to be startled at the minimum allowable strength and sections of highway bridges, especially those erected in remote localities to which freights are almost prohibitory, and where steep approach grades insure a very moderate maximum of traffic load. As a matter of fact, we are prepared to defend every feature of said bridge, and would state that the capacity asked for by the owner, and by his original engineer, Mr. Norman J. Nichols, M. Am. Soc. C. E. (now deceased), was considerably less than we felt willing to comply with. I have shown you the original letters from the owner, and Mr. Nichols' stating said capacity, and we have not only increased the total full-load capacity by a considerable percentage, but have also so locally strengthened the floor supports that no failure in detail can occur. The roadway was built so narrow that not only is it impossible dangerously to overload the bridge uniformly, but it is also impossible dangerously to overload either truss, as the fence line is kept well away from each truss. The entire structure was submitted, with price, in open competition, and was somewhat increased in strength after the work was awarded to us, as the details were worked out. We prefer to have definite statements made as to wherein the structure fails of security so that we can meet same by figures. We do not think it profitable to ourselves or your reading public to dwell on indefinite generalities. We will state that the owner of the bridge has been directed to forbid troops to march in step over the structure, but this is forbidden by the laws of this and other countries, and is not peculiar to the structure in question.

Yours truly,
H. S. Wood, Engineer San Francisco Bridge Co.
New York, N. Y., May 24, 1899.

Notes and Queries.

G. W. P. writes: In considering the various modes of transmitting power to the many auxiliary engines—or other motors used in battleships—it seems strange that no mention is made of compressed air, which is becoming such a favorite means of driving machinery in many railway shops. Hydraulic transmission also, under moderately high pressure, is worthy of attention. Neither are dangerous, as electric transmission is for such power.

The Monitor "Terror" is equipped with compressed air motors for operating nearly all the auxiliary machinery.

and is reported to be quite satisfactory. Mr. G. W. Dickie, of the Union Iron Works, San Francisco, has been prominent as an advocate of a general system of hydraulic power distribution for war vessels. Hydraulic power is, in fact, used there for many purposes already. Electrical transmission, however, is generally preferred by naval authorities. There is no danger in its use, as our correspondent seems to think, and the distributing wires are much more easily placed and kept in order than any piping system. Further, if a vessel with a general compressed air or hydraulic distributing system were struck and the piping pierced, the entire system might be rendered useless, and the vessel put out of action. Cutting the wires of an electrical system, on the other hand, would only affect the particular circuit broken, and the damage could be repaired in a few minutes. Besides this, the electrical system is much more economical of power.

SINGLE-PHASE DISTRIBUTION OF ELECTRIC CURRENT.*

By Herbert A. Wagner.†

Probably the best example of pure single-phase distribution on a large scale is furnished by the Missouri-Edison Electric Co., of St. Louis, and I can best show its possibilities by describing the results obtained by this company, but it is necessary to clearly define the position and sphere of single-phase work by way of introduction.

Simplicity is one of the prime requisites in an electrical installation, and the multiplication of parts or members decreases or eliminates it. It is hardly necessary to go into the details of the complications to which polyphase distribution may lead, but of these the multiplication of wires is the very least. The complication of the switchboard apparatus and appliances, and also those used in connection with local distribution and services is most discouraging.

Everyone who operates a large central station knows how impossible it is to separate light and power. Small motors are required by almost every lighting customer. If the solution then is to use single-phase motors for small powers, where is the size line to be drawn? Single-phase motors can be made just as efficient as three-phase. True they will cost more if so made, but when the saving in cost of transformers and distribution devices is considered, the balance is in favor of the single-phase motor.

It must of course be borne in mind that the subject now under consideration is general distribution for all electrical applications and not for power distribution alone. We might then be advised that we could confine our three-phase system to our transmission lines and feeders where we could save very greatly in the amount of copper required.

For ordinary distribution in large cities the cost of transmission lines or feeders is but a small proportion of the total cost, where alternating current is used. Of this small proportion we are told we can save 25% by the use of the three-phase system. But is this true? It is as far as copper is concerned, but the cost of insulation, conduits and other construction items does not increase in proportion to the cross section of the copper.

The actual difference in the cost of conductors installed for underground transmission between single and three-phase is almost insignificant. This slight difference can always be made up completely by operating the single-phase at a slightly higher pressure. If the cost of copper alone was considered the single-phase would have to be operated at a pressure 15% higher than the three-phase for equal cost. Considering the total cost of line installation, however, this difference would not be over 10% in pressure for overhead lines and less than 5% for underground lines. Have we ever so nearly reached the safe limit of pressure that anyone could say "you cannot safely go 10% higher?" Can we not as safely run 10% higher when we have only ¾ the length of line to operate and practically but ⅔ of the surface in contract with insulation from which leakage or breakdown might occur? As two-phase distribution requires the same amount of copper as single phase at the same pressure it has no point of even apparent superiority, except the debated one of greater adaptability for running motors.

On regulation—and this is a very important factor—the single-phase is far superior to the two-phase or three-phase system. I contend that it is impossible to keep two separate feeders supplying current largely used for lighting, equally loaded at all times, and it is therefore impossible to keep the different phase circuits of two or three-phase systems balanced when used for single-phase local distribution, and we have demonstrated that they must of necessity be so used in practice.

In either the two-phase or three-phase system, an unbalanced load on the different phases causes an unbalancing of the pressures on those phases at the generator and consequent difficulty in regulating closely, this being most marked in the three-phase system. In this particular and in slightly less complication in local distribution the two-phase system is superior to the three-phase.

In a large portion of St. Louis the usual system of individual transformers for every customer or adjacent customers is used. The current for these transformers is supplied by overhead feeders and distributed over high-tension overhead mains. In some districts one transformer is used to supply current for an entire block by means of three-wire low tension secondary mains.

The principal business portion of the city is now supplied by underground conductors, covering a district of 40 miles of streets. A low-tension Edison three-wire network of mains is used throughout this district, and these mains are supplied by high-tension feeders, each of which terminates in a transformer of the same capacity as the feeder. Pressure wires run from the mains near the terminal of each transformer back to the station. Each feeder has a regulator or booster at the station. From this network of three-wire single-phase alternating current mains, current is furnished for incandescent lamps, arc lamps and mortors.

As previously stated there are at present about 1,000 HP. of single-phase motors in operation, varying in size from ½ HP. to 25 HP. Many of these have replaced direct-current 500-volt motors, and there is not one that is not giving perfect satisfaction. Current is charged for entirely by meter.

The most novel feature of this system is the transformer and the method of making it practically a part of the feeder to which its drop is added and is cared for by the feeder regulator at the station. The pressure wires indicate the pressure on the secondary mains, which can be kept constant however much the drop in feeder and transformer may vary.

The transformers were designed for remarkably high average efficiency, and actually show the highest efficiency at about one-quarter load. The specifications for these transformers limited the iron loss to 250 watts, the copper loss at full load to 3,200 watts, and the regulation to 4%. Thirty of these, of 110 K-W. capacity each, are in service on as many feeders. They all run slightly under the specified losses. Tests on six of these transformers, picked out at random, are shown in Table I.

TABLE I.—Tests on 110-K-W. Transformers.

	Loss in watts.		Efficiencies, in per cent., load.		Regulation in %.
No.	Iron.	Copper.	Quarter.	Full.	
1	234	3,199	98.4	96.9	3.50
2	234	3,080	98.4	97.0	3.41
3	244	3,162	98.4	97.0	3.44
4	231	3,125	98.4	96.8	3.48
5	250	3,050	98.4	97.1	3.38
6	249	3,125	98.4	97.0	3.49
Specifications...	250	3,200	....	....	4.

The efficiency of this underground system of distribution naturally depends upon the losses in it and these are different at different loads. These losses have been determined for four loads and are given in Table II.

TABLE II.—Losses and Efficiency of Underground System of Distribution.

	Kilo-watts.			
Load at station	100.0	430.0	950.0	1,520.0
Feeder loss	0	12.3	30.0	66.3
Transformer iron loss.....	7.5	7.5	7.5	7.5
Booster iron loss	4.8	4.8	4.8	4.8
Transformer copper loss...	0	12.3	10.2	25.7
Booster copper loss.....	0		0.5	2.0
Sec'd'ry mains & h'se wir'g	0		19.0	45.6
Total losses	12.3	24.6	72.0	151.9
Energy delivered	87.7	405.4	878.0	1,368.1
Efficiency	87.7%	94.3%	92.4%	90%

The efficiency at 100 K-W. is the minimum efficiency; at 430 K-W. is the maximum efficiency. The station load of 950 K-W. was the average daily load at the time these tests were made, the maximum station load being 2,000 K-W. The average load for the year, based on the same maximum, would be considerably less than 950, and would therefore more nearly approach the maximum efficiency of over 94%. In these tabulated losses are included the losses in the feeder regulators or boosters. These being a part of the station apparatus are usually excluded in calculations of distribution efficiency.

The ratio of current delivered to customers as shown by customers' meters to the actual station output as shown by the station wattmeters, while not an exact measure of the distribution efficiency, owing to the losses in the customers' meters and their failure to record properly at small loads, is nevertheless a good indication for relative comparison. On the single-phase underground distribution system described, this ratio of customers' meter readings to station output reaches 86.2%. The meters used on customers' premises are the most recent type of induction wattmeters. The station meters are of the Thompson recording type, and these are carefully checked by the half-hourly records of station indicating wattmeters, both being frequently calibrated. A large portion of the current supplied on the overhead system is used in residences with individual transformers, and consequently the load factor is very low. The meters used in this work are recording ampere meters, which let a considerable amount of current slip by unrecorded with light loads. The transformers are all of modern design and of high efficiency for their size. It may surprise you, however, to know that the ratio of customers' meter readings to station output in this overhead distribution is only 48.3%.

The only strong argument that has ever been made against single-phase distribution is the contention that the single-phase current is not suitable for operating motors. Until quite recently it has not been shown positively that motors could be operated by single-phase currents as efficiently and with as great reliability as by two or three-phase currents. For over two years, however, we have been operating single-phase motors in St. Louis with the greatest success, and we now have about 1,000-HP. in such motors connected to our lines. As stated before, these motors vary in size from ½ to 25-HP. The efficiency is as high as that of direct-current motors, or two or three-phase motors, and in construction they are fully as simple and free from complication. The type used for constant speed work is started and stoppde by a single switch placed in any convenient location and without the use of rheostat or controller. A commutator is used to secure the required torque at starting and to bring the motor up to speed, after which it is entirely disconnected.

Our experience has shown that the cost of maintenance on these motors is very much less than that of direct-current motors, and as low as that of two or three-phase motors.

It has also been thoroughly demonstrated that single-phase alternating-current motors can be built for variable speed work and there are already many such motors in use where full torque is required at varying speeds, such as driving direct-connected elevators and operating ventilating fans. These motors are operated without commutator but require a controlling device for varying the speed. Full load torque can be obtained at any speed from zero to full speed; in fact, these motors can be controlled with as much ease as a series direct-current motor in such a way as to give a constant torque at all speeds.

A number of installations have been made in St. Louis of motor generator sets for transforming single-phase alternating current energy into direct-current for uses to which direct-current only is applicable. These outfits consist of induction motors directly connected to direct-current generators.

So far these has not been a single demand for current or energy for any purpose for which electric current has ever been used which we have not been able to supply efficiently from our single-phase alternating-current mains. This experience, and the knowledge that current is required for as many different purposes in the city of St. Louis as in any other existing city, lead me to state positively that single-phase currents can be used for general distribution to supply all requirements. As I have stated before, each class of current, single-phase, two-phase, or three-phase, has a field of its own; and the field in which single-phase current reigns supreme is that of general distribution.

*Abstract of a paper read before the National Electric Light Association, at its 22d Annual Convention, held at New York city, May 23, 1899.

†Supt. Missouri-Edison Elec. Co., St. Louis, Mo.

TRANSFORMER TESTS.*

By W. Elwell Goldsborough, M. Am. Inst. E. E.

In a paper read before this association last summer I outlined a series of tests which it was my desire to conduct upon the most improved types of the transformer to the end of finding more definitely than was then possible its true commercial status. In pursuance of this idea a general invitation was sent to the transformer manufacturers of this country to take part in a series of transformer tests to be conducted in the electrical laboratories of the Purdue University. The proposition involved the assumption on our part of an obligation to conduct high voltage insulation tests, full load working temperature tests, commercial efficiency and regulation tests, and an "ageing" test, to be extended, under full load working conditions, over a period of some months' duration. Five transformers were received at the University and these have been tested, as provided for, with gratifying results.

We are indebted to the General Electric Co., the Wagner Electric Manufacturing Co., the Fort Wayne Electric Works, the New York & Ohio Co., and one other company who preferred remaining unknown, for the use of modern transformers of their manufacture with which these tests were carried out.

The methods that have been followed conform to the best modern usage in such particulars, and the greatest care has been exercised, both in the frequent calibration of instruments and in the repetition of tests, to secure accuracy. A detailed statement of the schedule upon which the ageing tests were conducted will probably be of interest. The transformers were kept under full load and at 1,000 volts primary pressure from 1:30 p. m., till 11:00 p. m., daily except on Saturday and Sunday, when the run commenced at 6 p. m., and ended at 11:00 p. m. By this arrangement the transformers were under load for 10.5 hours a day, five days in the week, and were allowed to cool down to the temperature of the room in which they were located during the remaining 13.5 hours per day. On the other two days they were kept under a constant full load for 5 hours, and allowed to cool during the remaining 19 hours. The temperature of the room has averaged 25° C. throughout the tests, not varying more than a few degrees on either side of this value. The transformers may therefore, in comparison with ordinary out-door continuous service conditions, be considered to have been

*Abstract of a paper read before the National Electric Light Association at its 22d Annual Convention, held in New York city, May 23-25, 1899.

†Professor Electrical Engineering, Purdue University, Lafayette, Ind.

subjected to a continuous service test, during which they were kept under full load for one-third of the time. The highest actual temperature attained by the core iron in any one of the transformers has not exceeded 75° C. and the average maximum temperature per day of the cores at the end of a run of 10 hours' duration was not over 60° C. A daily record was kept of the primary voltage, secondary current, actual number of hours' duration of each run, and of the temperature of the room in which the transformers are located. If we assume that general service conditions are represented by a daily working schedule of half load for four hours per day, or full load for two hours, the transformers were subjected to a much harder service than they would naturally receive in 15 months, and to a service that is never likely to be equalled by any transformer in actual service if a comparison is made on the basis of the maximum temperatures attained. Only where transformers are used in connection with heavy motor power work are they likely to be subjected to duty that is equivalent to ten full load hours per day.

The high voltage insulation tests or break-down tests, were made at the end of the ageing tests. The tests were made at the voltages prescribed by the several manufacturers in the specifications submitted with the transformers, and with the result recorded in the detailed statement of each test.

A series of tests were made to determine the dielectric strength of the oils used to insulate the three oil insulated transformers. The tests were made by determining the voltage required to break down a gap of definite length between the points of ordinary No. 1 sewing needles used as discharge terminals. The samples of oil tested were taken from the supply coming with each transformer. They were drawn off when the transformers were first connected in and at intervals of about 300 full load working hours thereafter. The samples were only brought in contact with the air for a few minutes before each test, and in general a fresh amount of oil was taken from the sample for each discharge, the discharge being made between new needle points each time. The tests were made with step-up transformers, the source of power being a 7½ K-W. smooth core alternator, having a frequency of 125 cycles and developing a practically pure sine wave electro motive force. The voltage was controlled by changing the excitation of the field windings of the exciter by means of a rheostat arranged so that a very gradual and regular increase could be made in the voltage impressed on the needle points. The voltage readings were calculated from the readings of a standard voltmeter connected to the alternator terminals; the readings being multiplied by the ratio of transformation. The order of the tests was to gradually increase the voltage from 2,500 volts until the break down occurred. The discharge was limited by the blowing of a four-ampere fuse placed in a low voltage circuit that intervened between the alternator and the high voltage terminals.

The result of these tests are presented for the purpose of adding to the sum of our information regarding the exactness of the processes that are in general use in the manufacturing establishments of America, and are not intended to make any comparison as to the relative merits of the several transformers represented. The transformers were submitted for test under the general specifications issued in printed form and distributed freely to the public, and that the results of these tests have so nearly conformed to the general claims of the makers is a high tribute to the skill represented in the management of American factories. The fact is demonstrated that exact laboratory methods are the rule with our manufacturers, and it is one of which every engineer may justly be proud.

The "Packard" Transformer, Model '98, made by the New York & Ohio Co.—This is an oil insulated transformer of the core type, the coils being placed so that as much of their surface as possible will be exposed to the oil. The transformer is inclosed in the usual form of cast-iron case and is rated at 5 K-W. capacity. In a letter written at the time the transformer was shipped, the manufacturers say, "We have sent you a transformer 1,000 volts primary and 110 volts secondary. This we had in stock and was of a lot of iron that showed up rather poorly."

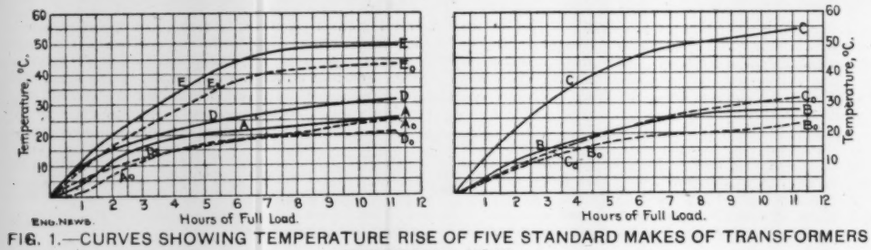


FIG. 1.—CURVES SHOWING TEMPERATURE RISE OF FIVE STANDARD MAKES OF TRANSFORMERS UNDER FULL LOAD.

"Packard."
A = Primary coil.
A_0 = Oil.
Wagner "Type G."
D = Primary coil.
D_0 = Oil.
Xxxx, Type Zzzz.
E = Primary coil.
E_0 = Oil.
General Electric Co.
B = Primary coil.
B_0 = Oil.
"Wood's" Transformer.
C = Primary coil.
C_0 = Iron core.

The facts set forth in the Table, in so far as they relate to the guarantees made by the company, are understood to be average values.

The regulation as determined experimentally by loading the transformer came out 1.82%. The copper loss of 1.6% which is based by the company on the cold resistances of the windings, comes between the hot and cold test values.

The core loss is about 15% higher than that specified, but owing to the relatively lighter copper loss the efficiencies even at low loads are not seriously affected. Indeed, if the experimental efficiencies were figured on the basis of a cold test they would be higher than the values specified. The iron used is of good non-ageing quality, and stood the service test well.

Although the manufacturers specify no high voltage insulation test, the transformer under discussion was subjected to a 10,000-volt test. The high voltage terminals were connected to the primary and secondary winding, to the primary winding and the core, and to the secondary winding and the core, for a period of 10 seconds. The transformer showed not the slightest tendency to break down under the test.

The results of the heat test are shown, graphically by curves A and Ao in Fig. 1. The transformer was kept under full load for the actual number of hours registered in the figure, the time needed for the taking of the readings being deducted. The full line (A) represents the temperature of the primary wire. The dotted line (Ao) the temperature of the oil. The temperature attained is low, and in this respect the transformer makes a very good showing.

The oil used in the transformer is a heavy cylinder oil. It was found by careful test to be free of mineral acids and of fat oils, but contained some water. The specific gravity of the oil was 0.880 at 50° C.; its flash point was 604° F. and its burning point, 656° F. Before the ageing tests and at a temperature of 25° C., this oil would run out of a bottle very slowly. As the tests progressed the oil became thicker and thicker. The samples of this oil were subjected to disruptive discharge tests in accordance with the statements made in the introduction. The general character of the results indicates that the power of the oil to resist a disruptive discharge is practically not affected by being constantly heated and cooled in service. The oil if anything improves slightly with age, as is shown by the higher voltages that prevailed in the last test and by the fact that the average distance between points after the discharge is less in the last than in the first test. On the oil being allowed to stand for a considerable time, a slight black scum would rise to the surface of the oil right over the point where the discharge had occurred. This indicated a breaking up of the structure of the oil with a probable change to higher and lower hydrocarbons, and the ebullition of some hydrogen gas. In fact when a successive number of discharges were made to pass through about an ounce of oil, the oil being stirred up after each discharge, the disruptive strength of the oil began to diminish after the fourth or fifth discharge. I should say, however, that the local insulating properties of the oil would not be seriously affected by a discharge under the oil unless the discharge was of a very severe character.

Type H., 60-Cycle Transformer, made by General Electric Co.—This is an oil insulated transformer of the "core" type. The coils are wound around rectangular iron cores, and have a large proportion of their surface in contact with the oil. The manufacturer claims that its transformers can be used within a range of 10% of normal voltage, and they are guaranteed to give average results in accordance with the data tabulated in the Table. The average increase in core losses due to ageing within a period of two years are to be on an average of not more than 3%, and maximum of 5%, when the transformers are operated with oil and not overloaded continously. The transformer was loaded non-inductively came out 2.62%, which tween primary and secondary and between primary and core, test current to be applied for a period of 10 seconds either with or without oil.

The test of the transformer brought out the fact that not only is the core iron used in its construction non-ageing, but that the total watts core loss in the transformer is about 3.2% less than called for in the specifications, and this brings up the low load efficiencies. The regulation is not quite so good as that called for in the specifications, but it is well within the limit of error of construction of stock transformers. The regulation by test when the transformer was loaded non-inductively came out 2,62%, which compares with the calculated regulation as determined from the hot resistance measurements. The calculated full load efficiency as determined from measurements at 20° C. is 96.4, which practically conforms to the specifications covering this point.

The heat test developed the fact that the increase in the temperature of the transformer is very gradual, and that it reaches a maximum after a ten-hour run. The temperature of the oil, as shown by the dotted curve of (Bo) Fig. 1, does not increase over 21° C. within the same period.

The break-down test was applied to its primary and secondary windings while the transformer case was oil filled. The test was repeated several times for ten seconds each time and at 10,000 volts. The results of this test were satisfactory,

The results obtained from the oil tests show that the resistance offered by the oil to disruptive discharges is high and improves somewhat with age. The properties of this oil do not differ especially from those of the other cylinder oil tested, except that it gets thinner with age instead of thicker. When first placed in the case it ran in a thick stream, but after 821 full load hours' use it ran quite freely. When the same sample was subjected to a number of discharges between points 0.06 of an inch apart, the sample showed no signs of weakening after five discharges at 14,250 volts had passed through the sample.

The General Electric Co. oil is a heavy cylinder oil that is free of mineral acids and of fat oils. It was found to

Values Guaranteed by Manufacturers and Results of Tests of 5-K-W. Commercial Transformers.

Specifications. Capacity, 5,000 watts. Test made at 60 cycles; power from iron-clad alternator.	Types of Transformers Tested. "Packard" model, '98. Economy test.		Gen. Elec. "Type H." Economy test.		"Woods" transformer. Economy test.		Wagner "Type G." Economy test.		Xxxx, Type Zzzz. Economy test.	
	Guarantee.	Lab. test.	Guarantee.	Lab. test.	Guarantee.	Lab. test.	Guarantee.	Lab. test.	Guarantee.	Lab. test.
Secondary voltage	110.0	110.0	104.0	104.0	110.0	110.0	100.0	100.0	100.0	100.0
Regulation, cold, %	...	1.51	2.0	2.29	1.8	1.72	1.9	2.00	2.0	1.77
Regulation, hot, %	2.0	1.74	...	2.63	...	2.16	...	2.32	...	2.12
Iron loss, full load, %	1.46	1.63	...	1.41	1.75	1.76	1.47	1.42	...	1.71
Copper loss, full load, cold, %	1.60	1.55	...	2.19	1.55	1.52	1.6	1.76	...	1.66
Copper loss, full load, hot, %	...	1.78	...	2.51	...	2.07	...	2.05	...	2.04
Iron loss, K-W.	73.0	84.3*	76.0	73.6*	90.0	92.6*	...	71.2*	84.0	88.9*
Copper loss, full load, cold, K-W.	...	79.9	...	113.5	80.0	78.4	...	91.1	...	86.0
Copper loss, full load, hot, K-W.	...	92.0	...	131.7	...	108.0	...	106.0	...	106.0
Efficiency, %, 0.10 load	87.1	85.4	...	87.0	...	84.2	87.0	87.4	...	84.7
" " 0.25 "	94.2	93.3	...	93.9	93.0	92.7	94.0	94.1	93.2	92.9
" " 0.50 "	96.2	96.0	...	95.9	95.8	95.4	96.3	96.2	96.0	95.6
" " 0.75 "	96.8	96.5	...	96.2	96.5	96.1	96.9	96.6	96.7	96.2
" " 1.00 "	96.7	96.6	96.5	96.1	96.7	96.2	97.0	96.6	96.8	96.3
" " 1.25 "	....	96.5	...	95.7	96.7	96.0	96.9	96.4	...	96.2
Temperature above air, full load test, Degs. Centigrade. After 5 hrs.	....	20.6°	...	20.3°	...	41.7°	...	23.7°	...	39.9°
Temperature above air, full load test, Degs. Centigrade. After 10 hrs.	....	24.9°	...	27.1°	...	52.1°	...	30.6*	...	49.9°

*This is the average of the values given in the table showing core ageing, and some intermediate ones not reported.

Note.—The efficiencies reported in the laboratory test were determined from results taken after a 10-hour full-load heat test. The guaranteed efficiencies are probably calculated using the cold resistances of the primary and secondary windings.

Results of Tests Made to Discover "Ageing" of Transformer Cores.

Hours of full load.	Core loss in watts. "Packard."	Gen. Elec.	"Woods."	Wagner.	Xxxx.
0.0	85.0	73.8	95.0	71.8	90.5
114.8	85.0	73.9	93.0	71.0	88.4
163.4	85.0	72.2	93.0	71.8	89.0
186.7	84.2	73.5	92.5	71.0	90.3
220.7	83.9	73.5	93.2	71.0	88.5
265.7	85.5	74.0	91.0	70.7	91.7
349.7	83.0	73.0	91.0	70.0	....
493.7	83.3	72.8	89.0	70.0	....
601.7	83.2	73.0	91.3	70.5	....
821.8	83.0	73.8	91.0	69.0	....

contain a slight trace of moisture; its specific gravity is 0.872 at 50°C.; its flash point, 516° F., and its burning point 570° F. as determined in the University laboratories.

In the matter of ageing the core iron behaved as well as could be desired and remained practically constant throughout the whole test. The core loss determinations are given in the Table, and are plotted in Fig. 2.

The "Wood" Transformer, made by the Fort Wayne Electric Works.—This transformer is of the "Shell" type, and is held in a cast-iron case affording special means of ventilation by air ducts with the idea in view of combining direct radiation with a good circulation of air in cooling the transformer. The transformer is not oil insulated. It is guaranteed to stand a 6,000-volt insulation test between adjacent coils and between the coils and the core, in addition to the specifications contained in the Table. No heating limit is specified, nor has any special ageing limit been specified, in the communications received by me from the company. These specifications are written on the basis of a test at about 20° C.

The test of the "Wood" transformer shows that it runs remarkably close to the specifications, and that in many respects it improves upon them. The "cold" regulation is

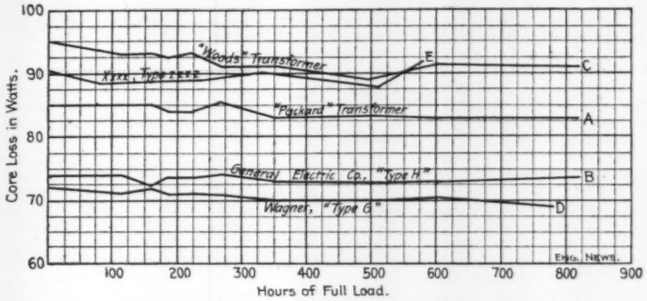


FIG. 2.—CURVES SHOWING RESULTS OF "AGEING TESTS" OF FIVE STANDARD MAKES OF TRANSFORMERS.

4.5% better than that stated in the general guarantee and the full load "cold" efficiency as determined from our results is 96.71%.

There was no ageing of the core iron during the tests. If anything the iron has somewhat improved, as the last test was made under the same conditions as the first test, i. e., when the transformer was cold.

In accordance with the specifications the transformer was subjected to a break-down test of 6,000 volts, which it stood in a highly satisfactory manner.

The heat test Fig. 1 (C and Co) developed the fact that the increase in the temperature of the core iron as determined by a thermometer placed in contact with the core was but little more than half as great as the temperature of the primary wire. It reached a value of 30° after a 16-hour run under full load conditions, while the temperature of the primary wire was 52° C. above the air.

"Type G" Transformer, made by the Wagner Electric Mfg. Co.—Transformers of this type are designed for use either dry or oil filled. The transformer tested was filled with oil supplied by the company, and all tests were made with oil insulation. Beyond the guarantees stated in the Table, the company specifies that the transformer will stand an oil-filled insulation test of 10,000 volts between the primary and second windings, between the primary and the case and between the secondary and the case, and, further, that 2,000 volts may be safely impressed upon the primary winding of any 1,000-volt transformer. The company guarantees all "Type G" transformers to show no marked deterioration in this respect within two years. The transformers are also guaranteed to stand a 25% overload for a period of three hours, without incurring damage to the insulation.

The effect of the circulation of the oil in reducing the temperature of the transformer as a whole is shown in Fig. 1 (D and Do) by the fact that the dotted curve of oil temperature falls 10° below the temperature of the primary wire.

The oil used in this transformer is a valve oil shown by test to be free of moisture and mineral acids. It is a pure mineral oil, no fat oil being present. Its specific gravity is 0.882 at 24° C. It flashes at 370° F., and its burning point is 425° F. When subjected to a high voltage break-down test the results obtained indicate very plainly that a structural change took place in the oil during the period of the ageing tests, that increased its value as an insulator, but caused a more violent discharge when break downs do occur. In its original state the oil was very light in color and several discharges might be passed through it without dulling the needle points or blackening the oil. Later the color was changed many shades, and after the ageing tests it had a deep wine color, and the needle points were dulled somewhat at almost every discharge.

The fact that the needle points were not materially blunted at any time is good evidence that the oil is a good insulator and that it acts in cutting off heavy discharges. At times after a very heavy discharge the oil will be blackened by a black cloudy material which after floating in the oil for awhile, finally sinks to the bottom. After the black material sinks the insulating qualities of the oil seem to be as good as ever. I do not think there is any free carbon after one of the severe discharges present in the oil.

The break-down test applied to this transformer consisted in connecting the high voltage terminals to the primary and secondary windings when the pressure had reached 10,000 volts. The result of the test was satisfactory.

Type Zzzz Transformer, made by the Xxxx Co.—With reference to this transformer the company sending it to our laboratories stated that transformers similar to the one under discussion are sold under the following specifications:

Capacity, 5,000 watts; frequency, 60 periods per second; minimum core loss (cold), 79.8 watts; average (cold), 86.5; maximum (cold), 93.3; minimum (hot), 73; average (hot), 80; mamimum (hot), 84; non-inductive regulation, 2% at 30° C. The company makes no temperature guarantees, but says that the transformers should rise about 45° C. after an eight-hour run. The efficiency of their transformers varies according as to whether the minimum, average or maximum core loss values are used. The efficiency should be about as stated in the Table. The core losses are guaranteed not to increase over 5% under normal working conditions. The transformers are designed to stand an insulation test of 5,000 volts alternating current, and are not of the oil insulated type.

The tests upon this transformer show that it is a good representative of the type. Its "cold" efficiency calculated from the test determinations, was 96.6% or just 0.2 of one per cent. less than that specified. The temperature elevation under load of the core and coils is shown in Fig. 1 (E and Eo), and is within conservative limits. The transformer withstood the break-down test at 5,000 volts; and, as shown in the Table, did not develop any special tendency to core ageing. Its regulation as determined by loading the transformer non-inductively is 2.2%.

In conclusion I will make no attempt at a general review of the results here presented, further than to call your attention to the curves contained in Fig. 2, and which are the graphical presentation of the ageing test records contained in the Tables. It is noticeable that the curves have a downward rather than an upward trend, and the question may arise as to the cause. In explanation I suggest that the changes are due to changes in the temperature of the iron as much as to anything else. The transformers were thoroughly cold when the first tests were made and have probably never reached so low a temperature since. In several instances when especially low values were recorded the tests were made after the transformers had been operated under full load conditions for several hours. I am disposed to think, therefore, that little if any change has taken place in the iron. A slight annealing of the iron may have occurred, but owing to the low temperatures attained during service by the transformers this is not very probable.

NOTES FROM THE ENGINEERING SCHOOLS.

Rensselaer Polytechnic Institute.—The 75th anniversary of the foundation of the Institute will be celebrated at the coming Commencement, June 13 and 14. On the 13th there will be an excursion by special train to Schenectady to visit the plants of the General Electric Co. and of the Schenectady Locomotive Works. Lunch will be served at Schenectady, and in the evening an alumni dinner will take place at Troy. On Wednesday a business meeting of the alumni will take place in the morning, followed by a lunch at the Troy Club. In the afternoon there will be an excursion by special cars to the Watervliet Arsenal, where a jacket will be shrunk upon one of the great guns now under construction. The Commencement exercises will take place at Music Hall in the evening. Captain Taylor, of the United States Navy, whose son will be graduated this year, will deliver the Commencement address. There will afterwards be a public reception by the Alumni Association to friends of the Institute. Many classes will hold reunions during the celebration of the anniversary.

Lehigh University.—Circulars have been issued outlining the course of instruction planned for the Summer school in civil engineering and surveying. The Summer school was organized in 1893 by the department of civil engineering, and since that time one or more courses in surveying have been given each year immediately after Commencement. These courses were open to all duly qualified applicants, but were taken for the most part by students of the University, who received credit for their Summer school work as an equivalent for the corresponding courses in the regular program of studies.

Beginning with the year 1898, the work of the Summer school was made a part of the regular program for each of the engineering courses. The required work now given in this way at the end of the academic year includes topographic surveying for students of civil and mining engineering, and shop visits for those of mechanical and electrical engineering. There are also given at that time courses in land surveying and in mechanical technology, which are not required, but which are taken by many students of civil and mechanical engineering.

In addition to the courses named, which are ordinarily given to students of the University only, it has been decided to offer a number of courses, in various departments, which will be open to all applicants who are duly qualified to take them. The principal object of these courses will be to furnish instruction for teachers in secondary schools, and they have been arranged, for the most part, with reference to the needs of such teachers. For sufficient reasons, it has been thought best that these open courses should not be given at the same time with those of the regular curriculum. The session of the Summer school will, therefore, begin on July 5, 1899, and close on August 16. All courses given at this time are open to women as well as men.

The fees for courses in surveying and in the chemical and physical laboratories are stated under their respective departments. For all other courses, including that in theoretical and experimental physics (Department of Physics and Electrical Engineering, Course A), the charges are as follows:

One course	$15
Two courses, taken by the same student	25
Three of more courses, taken by the same student	30

Applications for admission to the Summer school should be made to the Secretary of Lehigh University, South Bethlehem, Pa., before June 15.

Washington University.—A gift of $250,000 has been made to the University by Mr. Samuel Cupples for the endowment of a school of engineering and architecture. Of this sum, $100,000 will be devoted to the erection of a new building for these departments, and the remainder employed toward paying the running expenses. The gift of a dormatory building to cost $100,000 by Mrs. John E. Leggett is also announced.

RUSSIAN RAILWAYS IN 1898 are reported upon in the advance sheets of Consular Reports, of May 24, 1899, by Mr. W. R. Holloway, Consul-General at St. Petersburg. On Jan. 1, 1899, the Russian railway system included 28 connecting lines, of which 18 were controlled by the government and ten by private companies. The length of each of these lines is given, the longest being the Southwestern line, with 2,433 miles, and the Southeastern, with 2,288 miles. These connected 28 lines have a total length of 24,883 miles; but there are in addition 1,680 miles of lines not connecting with the general system—or, the Baskuchank, Transcaucasian and Transcaspian lines; and 293 miles of local lines. Not including the Finland railways, with their 1,590 miles, controlled by their own directors, there are in all 26,797 miles of Russian railways in operation. There were in addition, on Jan. 1, 1899, 7,015 miles of railway surveyed and under construction, with some of these open for construction purposes. The report notes a number of important projected lines for developing agricultural or mineral districts, or for shortening distances.

THE RUSSIAN MANCHURIA-PEKIN RAILWAY will be surveyed, says the London "Times," in spite of the protest of the Chinese officials. M. de Giers, the Russian

Minister to Pekin, has notified the Tsung-li-Yamen that Russia will at once send engineers to survey the country lying between Port Arthur and Pekin.

A MOTOR-VEHICLE RACE, from Paris to Bordeaux, a distance of 353 miles, was terminated on May 24. The winning vehicle was a petroleum motor, of 14 HP., with four seats. It made the run in 11 h. 43 m. 20 s., at an average speed of about 30 miles per hour, according to a despatch to the New York "Sun." There were 28 competitors in all. The good highways of France must be considered in connection with the average speed noted.

A NEW AIR-SHIP is being built at Burlington, N. J., on the plans of Prof. Charles Hite, a scientist who accompanied Lieut. Peary on one of his Arctic trips. He is being assisted by Mr. Charles King, an experienced aeronaut of Philadelphia, and the air-ship is a navigable balloon, cigar-shaped with fan attachments for driving it up or down or laterally. The two engines to operate the fans are being built at Trenton, and it is expected that all will be ready for an official trial early in June.

LIQUID FUEL is to be experimented with by the U. S. Navy Department on the torpedo boat "Talbot," now at Norfolk. The tests will be made at New York, and about 12 months will be spent in trying different forms of burners and systems.

THE BOSTON, CAPE COD AND NEW YORK CANAL Co. was incorporated by the Massachusetts House on May 26 by a vote of 126 to 29. This canal would be built on the Buzzard's Bay route—if built at all. Three other Cape Cod canal bills were killed.

A LEGAL DECISION OF INTEREST TO CONTRACTORS for public work in New York State has been handed down by the State Supreme Court in the case of Wm. J. O'Brien, of the New York Branch of the Granite Cutters' National Union, against the Commissioners of the New East River Bridge. The case arose out of the violation of the state labor laws by the contractors for the anchorages of the new bridge. At the time the contract was entered into there were two laws in force; one making eight hours a legal day's work for laborers, mechanics and workmen employed by the state or a municipal corporation or a contractor for public works, and, the other providing that all laborers, mechanics and workmen employed on any public work shall receive not less than the prevailing rates of wages in the respective trades in which they are employed in said locality. The contracts for the bridge contained clauses requiring the contractors to comply with the foregoing statutory requirements. Complaints were made to the Bridge Commission that the contractors were violating the laws and contract requirements as given. The Commission referred these complaints to the Corporation Counsel, who advised that: "It would seem to be the safer and better course for the Commission to wait and let the complainants take the case to the court and abide by the decision of the court, than to take any action at the present time in regard to declaring the contracts canceled by reason of the acts of the contractors said to be in violation of the statutes of the state." This advice was followed and the case was carried to the court, which decided that: It is the duty of the Commissioners to entertain and investigate complaints made against contractors engaged in the work of construction of violation of the provisions of the labor law, making eight hours a legal day's work and requiring the payment of wages at the prevailing rates in the locality where any public work is being carried on, and to act judicially in their discretion upon applications for forfeiture of contracts, as prescribed by the labor law, for such violations of the provisions aforesaid as may be established, especially if contracts for public work themselves expressly embody such provisions as to hours of labor and payment of wages. Any citizen has the right to institute and maintain a proceeding for mandamus to compel public officers to perform a public duty, although the relator has no private right to be enforced and no personal grievance to be corrected. This decision, it will be seen, is more wide reaching than the East River Bridge work merely. It makes it possible for any citizen and householder to compel contractors for public work to obey the statutory requirements of the state laws respecting hours of labor and the wages paid for this labor.

CRYSTALLIZATION AND SEGREGATION OF CAST IRON.*

By P. Kreuzpointer.†

Mr. West has pointed out very clearly in his paper that the present method of selecting pig iron by fracture is defective and misleading. How is the structure formed which we see on breaking a pig? A molten mass of iron in the blast furnace, cupola or ladle is a combination of chemical elements, held in solution by the fluid mass of iron, just as salt, or sugar, is held in solution by water.

Each of these elements has a different melting point and point of cooling. Some of these elements are attracted to each other, thus forming a combination. As soon as the iron gets cool enough, crystals begin to form and try to extract out of the surrounding fluid metal, all the elements necessary to their growth. The crystals grow as long as they have an opportunity to extract material for growth from the fluid iron surrounding them. Hence, if we cool iron quickly, we stop the crystal's growth while they are small. This is clearly shown by the samples exhibited here by Mr. West. The pieces of small cross-section have a fine structure, because they cooled quickly and the crystals had no time to grow larger. The larger sized sections have a coarse grain, because they had more time to grow, due to slow cooling. The fractures of the test bars exhibited by your committee on "Standard Tests," show the same phenomenon.

A couple of years ago I came across a very striking instance of the effect of time on cooling, on crystalline structure of iron and steel. A large part of the contents of an open hearth furnace escaped through the bottom of the furnace. The bottom was repaired and the metal was left there until the furnace had to be torn down. Here was an opportunity for the escaped fluid metal to cool very slowly. As a consequence the crystals in that mass of soft steel were of extraordinary size. I obtained a well formed crystal, which measured 1⅝ ins., in length and ⅝ ins. in width. I have still a piece of that metal with a crystal imbedded, measuring ⅝ ins. Ordinarily the crystals of such steel in the ingot measure only a few hundredths of an inch.

Such an instance furnishes proof of the importance and influence of time in cooling a molten mass of iron on the size of structure, irrespective of chemical composition. You can readily imagine the gradations in size of structure, due to time of cooling, between the crystal 1⅝ ins. long, and the fine structure we might be able to obtain in the same metal by instantaneous cooling of the mass. For the same reason, an iron low in silicon may have as coarse if not a coarser fracture, than an iron high in silicon and graphitic carbon.

There is another property of cast iron, with which foundrymen are much concerned, but which thus far has not received the attention it deserves. Cast iron is an alloy composed of iron and other substances. Now the melting point of alloys varies with their constitution. Thus wrought iron melts at 2912° Fah., gray iron at 2280° Fah., and white iron at 2075° Fah. An alloy of 1 part tin and 25 parts lead melts at 558° Fah., while an alloy of 6 parts tin and I part lead melts at 381° Fah. The melting point of tin alone is 451° Fah. and that of lead is 618° Fah. Naturally, an increase in the number of elements in an alloy and variations in the percentages of elements, will produce complications in the melting points of alloys. These complications are increased by the law of affinity, according to which certain elements will attract each other and combine with one another more readily than other elements. They will flock together like birds of a feather, as the saying is. It must be obvious that, during the formation of such complicated combinations the rate of cooling again plays an important part.

But to fill the foundrymen's cup of bitterness and perplexities to overflowing sometimes, and to make him scratch his head in wonderment as to what will come next, there is the phenomenon of segregation in alloys, and cast iron is much affected by this phenomena. Iron, like water, has the ability to dissolve and hold in solution, foreign substances when in a fluid state. But when a fluid mass of iron cools down to the point of solidification the foreign substances, held in solution while the iron was fluid, segregate out of the iron, one after another, the same as salt segregates out of the water, whenever there is more salt dissolved in a hot brine, than the water can hold when cold. Now the iron can hold more carbon, silicon, etc., chemically combined, when in a fluid state than it can hold in a solid state. Consequently, when a molten mass of cast iron freezes, such of the foreign substances held in solution by the molten iron as cannot be held by the solified iron, will segregate out during cooling until the mixture reaches certain proportions. The mixture with these proportions which freezes last, is called the mother metal in alloys of metal, and the mother liquor in other mineral solutions, for cast and pig iron are nothing but mineral solutions after all.

According to Roberts-Austen and Jueptner von Jonstorff, the mother metal of cast iron is composed of 95.7% of iron and 43% of carbon. The mother metal of an alloy of copper and silver contains 28% of the copper and 72% of silver. Whenever, therefore, in an alloy, an excess of elements is present above the proportions necessary to form the mother metal this excess will separate, or segregate out of the molten mass and solidify before the mother metal freezes or solidifies.

This is the reason why a plumber can make a wiped joint. If he would take a mixture of lead and tin, or whatever metals he uses, of such proportions as just to form the mother metal of a tin-lead alloy, he could not make a wiped joint, because his mixture would solidify under his hands so quickly, that no time would be left to wipe the joint. Having an excess of lead, however, this excess freezes first and continues freezing while the plumber is wiping the joint, until so much of the lead has frozen, or segregated out of the mixture, as to leave the proper proportion of metals to form the mother metal. When that point is reached, the whole of the mixture freezes at once without any further segregating out of the one or the other metal.

Now this same action takes place in cast iron, or other alloys, and this segregating out of the excess of elements in alloys, over and above those proportions necessary to form the mother metal, is a disturbing factor of unknown influence in the brass and iron foundry. On account of this, cast iron has two cooling points instead of one. In other words: the excess of elements present, over and above the mother metal, solidify or freeze, first and at a higher temperature than the mother metal. For instance, a mixture of cast iron with 98% of iron and 2% of carbon will solidify at 2408° Fah., but if the iron is given time enough to cool slowly for the segregating out of the excess of iron over and above 95.7% of iron and 4.3% of carbon, which is the mother metal of cast iron, than that iron will solidify at two different temperatures; viz.: the excess at about 2408° Fah. and the rest at 2066° Fah., which is the freezing point of the mother metal of cast iron.* According to Charpy, bronzes may sometimes have three, or even four freezing points.

The practical lesson for the foundrymen from all this is that if he knows he has the right mixture for a given purpose, to try and pour his iron at a sufficiently low temperature to prevent segregation as much as possible in large castings. Under unfavorable conditions such segregated castings, notwithstanding their chemical composition is all right, may be weak, because of the want of homogeniety of the structure. The casting may appear solid enough, but when a casting happened to solidify at two different temperatures, the structure or grain, cannot be uniform throughout the mass, and there is liability to lines of weakness running through the casting between the juncture of patches of coarser grain and finer grain.

We can thus readily see that it is not always the chemical composition alone that secures a good, strong and sound casting. We can also imagine what possibilities there are in alloys in general, and cast iron in particular, for the formation of an endless variety of combinations and complications, due to this peculiarity of segregation in alloys of metals, and the greater the number of elements present the greater the liability for complexities.

*Extract from discussion of a paper on "The Deceptive Fracture of Pig Iron," by Mr. Thos. D. West, read before the American Foundrymen's Association. (See Eng. News, May 25, p. 340).

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*Roberts-Austen and Jueptner von Jonstorff.

THE ANNUAL CONVENTION OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

The 22d Convention of this Association convened at the Madison Square Garden, New York city, on May 23, with a gratifying attendance. President Alden M. Young, of Waterbury, Conn., called the meeting to order and in a brief welcoming address stated that

Within the limits of New York city at the present time are located 35 electric light stations which furnish more than 1,000,000 incandescent lamps and 30,000 arc lights and at least 30,000 HP. in electric motors, representing an investment of nearly $100,000,000.

Referring to the street railways of Brooklyn he stated that the 10 railway companies, representing an investment of $55,000,000 and formerly operating as separate companies, owned 678 miles of track in 1897 and carried 223,180,504 passengers. In 1898, owing to the change to electricity, the capitalization had been increased to $150,000,000 and the number of passengers carried had reached 236,680,010.

Following the president's address, Mr. W. S. Barstow, of Brooklyn, N. Y., read the first paper, entitled:

"A Local Transmission System—Development and Operation."

This paper, by way of introduction, briefly considered the causes leading up to the design and construction of the great Union station of the Brooklyn Edison Lighting Co., where three-phase current is generated at 6,600 volts for transmission to the 10 substations of the company from which points currents of different characters are distributed over an area of 120 square miles.

Following this the question of station auxiliaries was discussed in some detail. This latter portion of the paper is reprinted elsewhere in this issue.

In the discussion which followed, Mr. Louis A. Ferguson, of Chicago, Ill., questioned the greater cost of steam driven auxiliaries. Admitting the smaller steam consumption resulting from the use of electric auxiliaries the fact that their first cost was greater than steam auxiliaries made the ultimate costs about the same.

It was stated that at the Harrison Street Station, in Chicago, Ill., the question was carefully considered, and that as a result electric pumps had been abandoned on account of the considerable cost of installation. This company did not consider electrical auxiliaries as reliable as those operated by steam. Mr. Walker explained that in the case of the Brooklyn Union Station they were using economizers, and generally speaking in such cases electrical auxiliaries were the best. Where economizers were not

used steam auxiliaries with the exhaust used for feed water heating should be first considered. If all steam used could be condensed and returned to the boilers, both systems were about on a par, where outside auxiliaries were used the saving resulting from the use of electric apparatus frequently amounted to as much as 10%.

If the station has a storage battery, as in the case of the Union Station, there was no danger of shut down and the system was thus rendered remarkably flexible.

Mr. Wagner, of St. Louis, wanted to know if the condition existing in the Union Station, namely, a high load factor, was not the one best suited for steam auxiliaries, since it would permit the most economical use of steam. Mr. Barstow admitted this, but maintained that his experience had shown that the electric system was more economical and generally satisfactory than the steam auxiliaries. In reply to the direct question, "Would you advocate a 25-cycle alternating system in preference to some higher frequency if you were to design the Brooklyn system over at the present time?" Mr. Barstow explained that there were many conditions entering into the problem, and it was more or less local. In any system where now or in the future ½ to ¾ of the output was to be served to the customers as alternating current, 60 cycles would be the proper periodicity. Where rotary converters were to be installed present practice, as indicated by the Niagara plant and many others, favored 25 cycles. Others argued on both sides and the discussion closed without any definite expression in favor of one or the other systems.

The report of the Committee on Standard Rules for Electrical Construction and Operation which was next on the programme was postponed, owing to the absence of Mr. William Brophy, the chairman.

The first paper of the afternoon session was presented by Mr. William Lispenard Robb, of Hartford, Conn., entitled:

"Rotary Transformers and Storage Batteries as Related to Long Distance Transmission.

The plant of the Hartford Lighting Co., which is the one considered, is a combination of long distance transmission with rotary converters and a storage battery plant at the distributing end, and this paper contained a statement of the conditions under which it is operated, of the difficulties met with in the operation of that particular plant, the way in which these difficulties have been overcome, and the advantages that have been found in the operation of rotary transformers and battery. We shall abstract this paper in a later issue. In response to questions, the author stated that the third or neutral wire of the three-wire system was absolutely neutral, and it was not possible in the present equipment to vary the voltage on the two sides although this could be done by inserting a small booster.

It was developed that Prof. Robb's work at Hartford was a most interesting experiment on a much larger scale than ever before attempted, and that the successful operation of the system dismissed the uncertainty as to the commercial efficiency of this system.

Attention was called to the fact that in connection with the system, series alternating enclosed arc lamps were being used with remarkable success. Prof. Robb stated that the first of these were installed about a year ago, two 100-light transformers for operating them being placed in a small substation with Bristol recording ammeters. The only attention necessary was to switch the current on the lamps and visit the substation once during the night as a matter of precaution.

Mr. Wagner called attention to the experience of St. Louis, when between 2,300 and 2,600 constant current series arc lamps were being operated from transformers in the central station. Regarding photometric tests of these lamps, Prof. Robb stated that the General Electric Co. had conducted tests which were quite satisfactory. In Hartford it was found advisable to supply 25% more power than would be furnished if the same circuits were operated with direct current.

The topic, "Transformers Tests," was given over to Prof. W. E. Goldsborough, of Purdue University, who read a report on the test of five 5-K-W. transformers under commercial conditions. This was an interesting exposition of what good transformers in small sizes may be expected to do, and it is abstracted elsewhere in this issue.

Mr. E. A. Leslie, New York city, introduced the discussion, describing his experience with transformers in the early days of their use. He had found that customers objected to oil insulation, owing to increased insurance rates, and that ordinarily they worked just as well without the oil. Apparently, transformers, even when made according to rigid specifications, did not last more than five years, and at the present time he was renewing many of those installed as late as 1895.

Questioned as to the temperature at which the test transformers were maintained when idle, Prof. Goldsborough stated that the room in which they were located was maintained at from 25° to 30° C. Regarding the life of transformers made five years ago, there was no question but that they did deteriorate. Present transformers, however, he considered on a par with other electrical machinery in durability.

Mr. Leslie repeated that he did not consider the life of transformers of any type more than 5, 6 or 7 years at most.

Prof. Robb pointed out the fact that there wer. three classes of transformer loads; lighting, in which the full load was on from 2 to 3 hours per day; induction motors or power which overloaded at starting and were at full load a large part of the day, and transmission loads which averaged 80% of full load at all times. In the test the transformers had been run at low temperatures, while in actual practice the temperature was more often 90° than 75°, and at those higher temperatures ageing was much more apparent.

It was suggested that the tests had all been conducted at one density, and that possibly tests made with successive periodicities such as 25, 60, 125, 133 might give different results.

Prof. Goldsborough, replying to this and other questions, stated that there were no magnetic effects comparable to the ageing which results from heating, whether it be done in ovens or by the transformer coils. Tests made by others had shown that frequency had no marked effect.

Mr. Wagner had at one time undertaken tests to determine what effect different magnetic core densities had upon core losses. In these, four transformers, constructed exactly alike, except that the amount of iron was varied from that necessary for normal core density to that producing four times the normal density. These were kept in continuous out-door service for three years with practically no ageing. Different kinds of iron gave, however, decidedly different results. Mr. Wagner considered that the ordinary working temperatures had very small effect on the iron.

Prof. Goldsborough explained that it had been found by experiments in England that as the temperature of iron cores was increased up to 75° little effect upon the core loss was apparent from this point on to 300° there was a marked increase after which a falling off occurred, and at 750° the iron apparently resumed its original condition.

The Wednesday morning session was opened by Mr. Herbert A. Wagner, of St. Louis, who read a paper on

"Single-Phase Distribution."

In this paper, which is abstracted elsewhere in this issue, the advantages of the single-phase system were clearly set forth by referring to the example of St. Louis, where the Missouri-Edison Electric Co. are operating such a system with an output of about 2,000 K-W.

At the conclusion of the paper, Mr. O. T. Crosby asked if there were any considerable number of elevators on the single-phase system described and if both motor and lighting customers were pleased. Mr. Wagner stated that there were a number of elevators.

That there was practically no fluctuation in voltage as could be seen from the record of the Bristol recording voltmeter accompanying his paper. On the circuit from which this was taken was a 25-HP. motor, and it was impossible to detect the starting of this motor. He also called attention to the possibility of having an interconnected system of feeders in the single-phase system, which is not practicable with the polyphase systems. Mr. W. L. R. Emmet, Schenectady, N. Y., suggested the method of using a single three-phase generator for a single and a two-phase system, one of the three-phases being used for the section contiguous to the generator, while the other phases would serve for a two-phase transmission for outlying districts. He further suggested a method of converting a three-phase generator into a single-phase machine by cutting out ⅓ of the coils and leaving ⅔ of the armature surface covered with active conductors. This system was in use in Syracuse, N. Y.

Mr. Crosby asked the author whether in his judgment the single-phase alternating system could compare with the direct-current system for operating both lights and motors from the same mains. He asked this because it was of vital importance with his company, in common with many others, to know whether to advocate the low-tension, direct-current Edison three-wire system or to convert gradually present apparatus and finally swing over into the use of single-phase alternating current.

These questions, Mr. Wagner said, could not be answered by either yes or no. In St. Louis they had experienced no difficulty in satisfying all sorts of customers. They had, however, had trouble in getting customers previously using direct-current apparatus to change over to the alternating.

With proper care in the design of the system, the variation in line voltage could be made quite as small as with the direct-current system, owing to the high-power factor of alternating current motors at starting. Direct-current motors were, however, cheaper in first cost. He favored single-phase alternating current where a station was to extend its field, because it was more flexible, but did not wish to make the broad statement that this would hold in all cases, for local conditions always deserved full consideration.

Mr. Louis A. Ferguson cited the case of Chicago, where the territory of the company with which he was connected included some 33 sq. miles. The question of the use of alternating current came up, and a committee of the company's engineers was appointed to consider the subject from all standpoints. It was reported adversely, and the statement was made that the use of motors larger than 2 HP. would jeopardize the company's lighting interests. He admitted that in the downtown section of St. Louis the system was working very well, but he questioned its sucess in the outlying sections.

Mr. Wagner again stated that the system could work as well at a distance as near at hand, but before installing a large motor it would be necessary to consider carefully the feeders from which current would be taken to supply such a motor. The usual fault and the cause of past failures has been that no attention has been paid to the proper proportioning of feeders.

In further explanation of his remarks about using the alternating current system for extensions, he said that if the present output of any given station was half of what was expected 10 years from now, it certainly would not pay to throw out the machinery now in use and install alternating apparatus. If, on the other hand, the present output formed only a small proportion of what was looked forward to in the future, say a tenth, then it would, in his estimation, be expedient to change gradually over to the single-phase alternating system.

Mr. Perkins added that the size of generators furnishing current to the system had a great deal to do with fluctuations in voltage—the larger the generating unit the less the voltage variation in any given case. In response to a request from the Chair, Mr. Emmet discussed this subject, and stated that it was simply a question of enough copper in feeders, high enough voltage or large enough generator. The larger the machine the better the regulation. Generators could be designed to be close regulating, although it was not desirable to carry this too far, since it cut down the efficiency of the machine. The present trouble was that most station managers were only familiar with the small alternators, and did not appreciate the possibilities of the larger generators, which have an inherent regulation of from 4½% to 5%. That is, they will not vary in voltage more than 4½% to 5% when the full load is thrown on or off. If several such machines are operating in parallel, it would be possible to throw on a 100-HP. motor with no appreciable effect.

In closing the discussion the Chairman remarked that the matter sifted down to what might be termed three zones, the first or inner one near the central station in which there was little question as to the wisdom of employing direct current, then there was a remote zone where some form of alternating current was essential, owing to transmission difficulties. The intermediate zone was where the question arose.

The next paper, by Mr. Louis A. Ferguson, of Chicago, was entieled:

"Underground Electrical Construction."

It proved to be a clear and valuable resume of the subject of conduit construction, with tables as to costs of excavation and subway construction for different services and under various conditions. This paper we also postpone to a later issue. The discussion was very brief, and only developed the fact that several members were experiencing trouble with their Edison conduits, owing to electrolysis. The first paper of the afternoon session, entitled:

"Some Notes on Underground Distribution of Two-Phase Current in New York City."

was by Mr. E. A. Leslie, New York city. This paper outlined the subway system of New York city, and described the various methods employed by the Manhattan Electric Light Co. to determine faults, insulation, etc.

There was no discussion on this paper. The second paper of the afternoon, by Mr. W. L. R. Emmet, of Schenectady, N. Y., was a discussion of the interesting subject,

"Means of Affording Safety in Electrical Distribution."

The intention of this paper, and it is so stated by the author in his introduction, was for the purpose of calling to the attention of the Association certain matters of practical importance, concerning which radical differences of opinion exist among persons prominent in the electrical industry, and also for the purpose of pointing out some of the new problems which have been presented by recent developments of the electrical art and which have not been fully considered in the adoption of present standards of practice.

The first of these was the Fire Insurance Underwriters' rule prohibiting the grounding of any electric lighting circuits. Mr. Emmet advocated a system in vogue abroad, which permits the grounding of one side of the secondary circuit of high-tension systems. Several methods of accomplishing this result were explained in the paper. As an example of the need of a revision of the ruling against grounding secondaries, the recent New Orleans fire was mentioned. In this a main wire and a 2,000-volt primary wire became crossed, resulting in the breaking down of the insulation between the wiring and the ground in fully 20 houses. The resulting fires destroyed fully $200,000 worth of property. The remainder of his paper was a consideration of fuses and circuit breakers for protecting and interrupting circuits where, as in the case of the Niagara plant, or the New Metropolitan station in Now York city, heavy currents at high voltages are to be broken.

The principle of all devices for this purpose which have so far met with success is to enclose the opening contacts in tubes or spaces so that the arc which invariably forms will generate gas or heat the enclosed air sufficiently to cause an explosive draft of air, which blows out the arc. Several devices of this sort with which the author has had successful experience were illustrated in the paper.

Mr. Sachs stated that his experiments had indicated that some fuses worked all right on high tension, and yet would fail on low tension circuits. In cases where fuses were used in multiple across circuit breakers, if both opened at the same time an arc would be established across the circuit breaker, and it was therefore necessary for the fuse to blow after the circuit breaker.

Mr. Barstow mentioned the experiments conducted at the Union Station in Brooklyn to secure reliable fuses and circuit opening devices and stated that they had finally secured apparatus based on those described in the paper which worked perfectly.

In England he had observed the use of fuses immersed in oil for pressures as high as 3,000 volts, while in Milan, Italy, in the case of a 13,000-volt circuit they were successfully using fuses enclosed in porcelain tubes. The fuses in these were, however, arranged to always fail at the center.

Mr. S. Dana Greene briefly discussed the importance of having the rule revised which prohibited the grounding of secondary circuits and moved the appointment of a committee to consider this matter.

As to the relative merits of alternating current and direct current arc lamps the discussion developed the fact that the direct current series arc lamp is more satisfactory at the present time than the alternating current arc lamp. The objections cited against the alternating arc lamp were its noise and unreliability. In reply to questions Prof. Goldsborough stated that the direct current arc lamp is more efficient from the wattage standpoint and throws more light on the ground, owing to its crater having a fixed position in the upper carbon. The direct current enclosed arc affords a much better distribution of light than the open type, although the alternating current arc lamp has a more uniform spherical distribution. Roughly speaking, the enclosed arc lamp with the old style transparent globe required 3½ to 4 watts per candle power. Experiments had shown that the direct current lamp was better adapted for high positions to light large areas than the alternating lamp.

Mr. Crosby suggested that there was a large field for a small arc lamp which would have a long life, require little attention and have a small current consumption, a lamp which could be placed in stores to compete with the Welsbach gas lamp.

In reply to a general question it was stated that any form of electric heating apparatus would work as well with alternating as with direct current.

Owing to the absence of Mr. E. A. Armstrong, chairman of the Committee on Legislation Regarding Theft of Electric Current, no report was received from this committee.

In the evening a very interesting illustrated lecture was presented in the main lecture room of the Madison Square Garden By Mr. Calvin W. Rice. The lecture was on "The Development of High Tension Service," and while popular in character was worthy of the attention which it received.

Thursday morning's session included a paper on

"Alternating Current Generation and Distribution —Changes Contemplated in Atlanta."

By H. M. Atkinson, Atlanta, Ga.

In this paper the author outlined the present equipment of the lighting company with which he is connected. Referring to the reason for the contemplated change he said:

We feel that we have a company in Atlanta that is a success. It has paid the people well who invested their money in it, and is doing so to-day. It is producing current at what we consider a low cost per kilowatt. With a successful record in the past, with everything running smoothly and satisfactorily, and with a bright outlook for a constantly increasing business, it is a hard thing to face radical and expensive changes, but the growth of our business forces us to act. We concluded early in the spring that we must have increased capacity to carry our load during the coming fall and winter. Two alternatives faced us: First, should we go on and add in conformity to our present equipment or, second, should we depart radically from our past methods and, as it were, take a fresh start.

Following this the various requirements of the service were considered in some detail. The plan finally adopted was outlined as follows:

1. We shall have large and few units, which means economy in steam and station attendance.

2. We shall have multiple running, which means even service and the highest efficiency in engines and generators, by keeping as nearly a full load as possible at all times.

3. By using motors to drive our arc machines, attendance will be cut down and saving effected in repairs, belting losses and losses in shafting; or should we decide on "tube" and series alternating arcs, we shall have all the foregoing and the additional advantages of steadiness, reliability, less attendance and higher efficiency.

4. We believe our incandescent customers will be served as perfectly as with a single-phase plant.

5. If we have to continue our 500-volt motor circuit for some classes of work, it can readily be run from rotaries and so increase the day load on our generating units.

It has been our policy in Atlanta to keep our prices for all classes of service at the lowest possible point, believing that this is the only way to keep our customers satisfied, and at the same time hold exclusive control of our field. Our policy has proved correct to the present time. To continue this policy, we must necessarily discard such machinery as cannot be run with the economy to be expected from our station to-day, and which we must attain to render our position unassailable. We shall have made heavy sacrifices for standard machinery, but we believe the manufacturing business has reached a stage to-day which enables us to do this, and that we shall be repaid in the long run. Are we undertaking too much in our endeavor to get away from the multiplicity of units.

In discussing this paper the question of supplying current for charging electric vehicles was raised and provoked many interesting expressions of opinions. It is worthy of comment that this is the first time that the motor vehicle problem has been recognized officially by any of the electrical societies as an important adjunct and possible source of considerable revenue to electric light companies.

Mr. Crosby remarked that the motor vehicle problem was to-day about where the street railway business stood in 1889. He wanted to know what was the best method to employ to cultivate this business. President Young stated as his belief that the motor vehicle business had come to stay, and that the association should adopt some definite plan to facilitate this growth, for it would, in his estimation, bring rich returns to the lighting companies in the future. Mr. Booth considered it a matter for each central station to work out for itself. So far 110 volts had been adhered to, but there was no reason why other voltages could not be employed.

To draw out the discussion Mr. Crosby suggested two extreme cases; the one in which all charging would be done from one central station, and the other employing charging posts resembling lamp posts, to be erected at street corners.

It was quite generally agreed that neither of these systems was the proper one, and that a number of charging stations would be necessary even in a city of moderate size.

President Young called attention to the splendid opportunity afforded by motor vehicles to bring up the day load of a central station.

Mr. Scovil described a battery charging equipment in Cleveland, O., which takes alternating current from the alternating mains and transforms it to low-tension direct current suitable for battery charging. This idea was favored by several, and it was pointed out that as the storage battery required time to charge, the scheme of having street charging posts would be found impracticable, except in the case of emergency. In New York city current was furnished to the automobile company at the rate of 5 cts. per kilowatt hour. At this rate 1,000 lbs. could be carried one mile for 0.6 cts. expenditure for power.

One speaker said that ultimately the owners of automobiles would run their carriages into the basements of their houses and leave the charging to the butler or the cook. The present trend of the motor vehicle business seemed to be towards isolated charging plants, an example of which was afforded by Altman & Co., of New York city, which is at present installing an extensive plant for charging its motor carriages.

Mr. Barstow said that the kind of service to be adopted in extensions depended entirely on what the public wanted. If an alternating system were adopted the customer could perhaps be induced to use rotary converters, but only when he could not get direct current from some other company.

The opinion was expressed that direct current was favored by the public because there was an impression that anything connected with alternating current was dangerous.

Another paper, entitled

"Transformers, Iron Loss—Its Increase—The Remedy,"

was presented by Mr. G. Wilbur Hubley, of Louisville, Ky. In this attention was called to the results of a series of experiments made with transformers of various types of manufacture, and covering periods of service from 1894 to 1899.

The system employed, and fully outlined in the paper, consists in unwinding the coils of transformers as soon as they begin to indicate any perceptible "fatiguing," as shown by the increased core loss determined by frequent tests, and carefully annealing the iron sheets composing the core; the coils being afterward rewound. The data presented showed that in some cases the core loss increased as much as 100%, and that this loss could be greatly reduced and the core returned nearly to its original condition by the process. It was estimated that the cost of the treatment varied from 22 cts. per K-W. on sizes of 25 K-W. to $2.20 per K-W. on transformers as small as ½ K-W.

The paper included a set of general specifications adopted by the company with which the author is connected, on Jan. 1, 1899. These are as follows:

Specification Limits for Efficiency and Regulation of Transformers. Adopted Jan. 1, 1899.

Capacity.	Iron loss. K-W.	Iron loss. Per ct.	Regulation, per ct.	Capacity.	Iron loss. K-W.	Iron loss. Per ct.	Regulation, per ct.
500	35	7.0	3.0	6,250	125	2.0	2.0
600	36	6.0	3.0	7,500	150	2.0	2.0
1,000	45	4.5	3.0	10,000	175	1.75	2.0
1,250	45	3.6	3.0	12,500	200	1.6	2.0
1,500	51	3.4	3.0	15,000	210	1.4	2.0
2,000	60	3.0	3.0	18,750	225	1.2	2.0
2,500	65	2.6	2.5	20,000	240	1.2	2.0
3,000	75	2.5	2.5	25,000	275	1.1	2.0
3,750	90	2.4	2.5	30,000	300	1.0	2.0
4,000	90	2.25	2.5	37,500	375	1.0	2.0
5,000	110	2.2	2.25	50,000	500	1.0	2.0
6,000	120	2.0	2.25				

Insulation test to be made by a series of make and break contacts, and one prolonged contact, as follows:
1. Between primary and secondary coils, 6,000 volts A. C.
2. Between primary coil and core, 6,000 volts A. C.
3. Between secondary coil and core, 1,000 volts A. C.

Temperature test measured by thermometers placed in mercury cups in core of transformers. Increase above surrounding atmosphere on full load tests of eight hours' duration must not exceed 60°.

Fatigue.—Iron loss must not exceed 10% increase above limits, as specified, within period of two years' service.

Overload.—Transformers must be guaranteed to stand overload of 25% above rated capacity, for duration of two hours, with temperature increase not to exceed 60° C. above surrounding atmosphere.

General Guarantee.—Transformers must be guaranteed for two years' service against burn out from any cause (including lightning), providing same are under normal conditions of service.

Remarks.—The above specifications do not contemplate the use of oil in transformers.

In case of failure of transformers furnished under specications, all expenses of rejection shall be borne by the manufacturer.

Initial tests on all transformers should be made when received, and these should be repeated under similar conditions as often as opportunity permits, i. e., at all times when transformers were brought into station from service.

The business session was concluded by the presentation of reports from standing committees. The first of these was from the "Committee on Specifications for Electrical Apparatus," by Mr. Paul Spencer.

Mr. Spencer said the committee had decided that it would be inadvisable to formulate other than very general specifications, because, owing to the very rapid changes of the electrical industry, detailed specifications would handicap manufacturers. It would, therefore, be best to simply specify limits within which manufacturers could work.

The technical side of the question was being considered by the American Institute of Electrical Engineers, and its report, when submitted, should be used as a basis for anything done by the National Electric Light Association.

As to the size of units, the manufacturers should be consulted. The kinds and sizes and speeds of steam engines for operating generators was at the present time being considered by a committee of the American Society of Mechanical Engineers and the report of the committee would furnish much needed material.

Mr. James I. Ayer, reporting for the committee on "Amendments to Freight Classifications," stated that strenuous efforts had been made on the part of the committee to harmonize the freight rates on electrical apparatus with the rates charged on similar materials. That nothing had been accomplished, owing to the stand taken by the railway freight classification committee, which had persistently refused to change the rating from first to third or fourth class.

There were three courses open to the association, these were to apply to general managers of the railway complaining of the unfair rating, another was to appeal to the Interstate Commerce Commission, and the third and last was to take the matter to the United States Supreme Court.

Mr. Crosby suggested buying all goods f. o. b. at its destination. This was objected to, however, on the ground that it would simply result in an increased cost to the consumer without correcting the trouble.

It was finally decided to prepare a resolution requesting the members to use every individual effort to bring the matter to the attention of local agents. The committee was continued and requested to furnish members with material which would show how discriminations were made against electrical apparatus.

The report of the Committee on Finance was practically the same as the Treasurer's report, and showed:

Total income for year	$7,188.90
Disbursements	4,364.78
	$2,364.72
Assets	$3,502.63
Liabilities	865.58
Net assets	$2,637.05

Other routine business was transacted, after which the association went into executive session to consider the report of the Committee on Legislative Policy, and elect officers.

The following were elected: Pres., W. W. Carns, Memphis, Tenn.; First Vice-Pres., O. T. Crosby, Washington, D. C.; Second Vice-Pres., J. B. Cahoon, Elmira, N. Y.; Secy. and Treas., George F. Porter, New York city; Master of Transportation, C. O. Baker, Jr.; Executive Committee, F. A. Copeland, W. W. Bean, W. McLea Walbank, Samuel Insull, Samuel Scovil, H. M. Atkinson, E. F. Peck, W. M. Brock and C. S. Scott.

The social features of the convention consisted in an automobile ride and parade, held on the afternoon of the second day, in which about 50 motor vehicles of all sorts participated. Thursday, from 11 a. m. to 5 p. m., the lady visitors enjoyed a sail around Manhattan Island.

Thursday evening Mr. Calvin W. Rice delivered a lecture, already mentioned, while Friday was occupied with a trip to the works of the General Electric Co., at Schenectady, N. Y., a special train being run up for the purpose by the General Electric Co.